United States
Department of
Agriculture

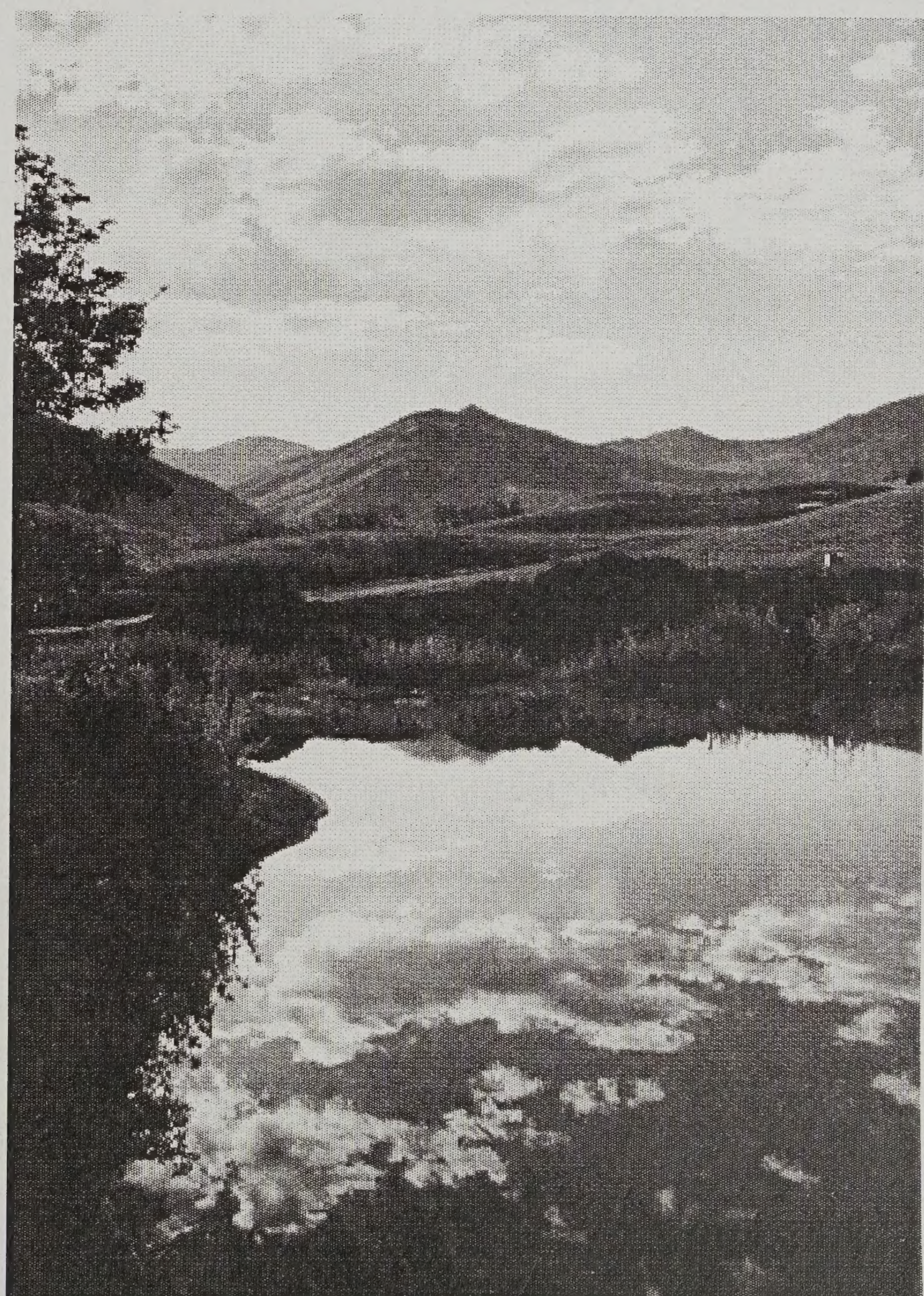
Forest Service

Forest Health
Protection

Forest Health
Technology
Enterprise Team-
Davis
2121C Second Street
Davis, CA 95616

SIXTH REPORT

NATIONAL SPRAY MODEL AND APPLICATION TECHNOLOGY STEERING COMMITTEE



FHTET 96-14
August 1996

Pesticides used improperly can be injurious to human beings, animals, and plants. Follow the directions and heed all precautions on labels. Store pesticides in original containers under lock and key—out of the reach of children and animals—and away from food and feed.

Apply pesticides so that they do not endanger humans, livestock, crops, beneficial insects, fish, and wildlife. Do not apply pesticides where there is danger of drift when honey bees or other pollinating insects are visiting plants, or in ways that may contaminate water or leave illegal residues.

Avoid prolonged inhalation of pesticide sprays or dusts; wear protective clothing and equipment, if specified on the label.

If your hands become contaminated with a pesticide, do not eat or drink until you have washed. In case a pesticide is swallowed or gets in the eyes, follow the first aid treatment given on the label, and get prompt medical attention. If a pesticide is spilled on your skin or clothing, remove clothing immediately and wash skin thoroughly.

NOTE: Some States have restrictions on the use of certain pesticides. Check your State and local regulations. Also, because registrations of pesticides are under constant review by the U.S Environmental Protection Agency, consult your local forest pathologist, county agriculture agent, or State extension specialist to be sure the intended use is still registered.

Cover Photo
Mountain Dell golf course, Parley's Canyon, Utah. Site of the 1991-1993 gypsy moth aerial spray program and drift studies. Photograph by John Barry, 1991.

FHTET 96-14
August 1996

Sixth Reort

National Spray Model and Application Technology Steering Committee

Prepared by:

John W. Barry
Chairperson
and
Pat Skyler

USDA Forest Service
Forest Health Technology
Enterprise Team
2121C Second Street
Davis, CA 95616
(916)757-8342
FAX (916)757-8383

CONTENTS

I. INTRODUCTION

The meeting was held in Phoenix, AZ, July 17 and 18, 1996 in conjunction with the International Summer Meeting of the American Society of Agricultural Engineers (ASAE). The meeting call letter and agenda are in Appendix A. This scheduling provided for economies in travel as several members of the committee presented papers at the ASAE meeting or otherwise attended the ASAE annual meeting on a regular basis.

A. Attendees

Name	Organization	Phone Number
Jack Barry	USDA Forest Service	(916) 757-8342
Bob Mickle	Environment Canada	(416) 739-4851
Dave Davies	Forest Protection Ltd.	(506) 446-6930
Harold Thistle	USDA Forest Service	(406) 329-3981
Parshall Bush	University of Georgia	(706) 542-9023
John Ghent	USDA Forest Service	(704) 257-4328
Jules Picot	Univ. of New Brunswick	(506) 453-3542
Brian Richardson	Forest Research Institute New Zealand	64 7 3475516
Clarence Hermansky	Dupont Agri. Products	(302) 695-1816
Alina MacNichol	Continuum Dynamics, Inc.	(609) 734-9282
Milt Teske	Continuum Dynamics, Inc.	(609) 734-9282
Pat Skyler	USDA Forest Service	(916) 757-8343
Bill Jorden	B.W. Jorden & Co., Inc.	(520) 297-4017
Harry Hubbard	USDA Forest Service	(203) 734-9168
Dave Esterly	Dupont Agri. Products	(302) 695-1690
Jim Rafferty	US Army Dugway Proving Ground	(801) 831-5101
Bruce Grim	US Army Dugway Proving Ground	(801) 831-5101
Bill Steinke	Univ. of California Davis	(916) 752-1613
Dan Haile	USDA-ARS	(352) 374-5928
Terry Biery	USAF Reserve, Aerial Spray	(330) 392-1178
Dave Whiteman	Battelle NW Labs	(509) 372-6147
Ellis Huddleston	New Mexico State University	(505) 646-3934
Richard Derksen	Cornell University	(607) 255-9555
Robert Fox	USDA-ARS OARDC	(330) 263-3871
Dave Valcore	DOWELANCO (SDTF)	(317) 337-7933
Nicholas Woods	CPAS Univ. of Queensland Australia	61 74 601293
Robert Fusco	Abbott Labs	(717) 436-5043
Heping Zhu	USDA/ARS	(330) 263-3868
Andrew Hewitt	SDTF (Stewart Ag)	(816) 762-4240
Bill Bagley	Wilbur-Ellis	(210) 657-0953

B. Purpose of Committee/Meeting

The purpose of the committee is:

1. To exchange national and international information on spray model and application technology development activities;

2. To facilitate cooperation, partnerships, and economies;

3. To identify model and application technology needs; and

4. To support the advancement of technology for the safe, economic, efficacious application of biorational and other pesticides.

The purpose of the meeting was:

1. To provide an opportunity for participants to informally report on their spray model and pesticide application technology activities in agriculture, forestry, and insect vector control;

2. To identify technology needs and encourage partnerships and cooperative projects; and

3. To obtain participant's comments on future need, opportunities, charter, sponsorship, and leadership of this committee.

II. DISCUSSION

The discussion as presented herein is a summary of remarks by attendees and/or a summary of their work. Some attendees provided a more detailed summary which is enclosed in the Appendices.

A. Attendees Remarks and Reports

Dave Esterly

Regarding the Spray Drift Task Force (SDTF) AgDrift model -

. See report in Appendix B.

. AgDrift, version 2.0, is coming out in June 1977 and will also have an orchard model in it in addition to the aerial and ground. AgDrift is a regulatory model.

. The AgDrift model will eventually be available to the public less the SDTF database. Reasons for this is legality under FIFRA law. FS, Army, etc., can request the database under the freedom of information act.

. DROPKICK - is another SDTF model that predicts drop size distribution.

. 38 companies are members of the SDTF.

. 180 SDTF field studies done.

. This committee is important to maintain.

Harry Hubbard

. Works for the FS, Microbial Control Project in Hamden, Ct - registrar for Gypchek for entire country.

. Presented a slides on production of the gypchek virus.

. Is a specialist on spray equipment.

Dave Whiteman

. See report in Appendix B.

. Is preparing a field manual title - Complex Terrain Meteorology - A Manual for the Natural Resource Manager. It will be approximately 150-200 pages and illustrated in color. Sponsors are FS, Department of Energy, US Army, and National Weather Service.

. Dave Esterly suggested that the manual also be put on CD ROM.

. Dave Esterly said he had some pictures of low-level inversion that he will give to Dave for the manual.

Dave Davies

. See report in Appendix B.

. Objective in control operations is both efficacy and environmental protection.

Bob Mickle

. See report in Appendix B.

. Demonstrated via slide presentation on practical uses of FSCBG for mosquito control.

. Model enabled him to look at drift rather than just deposition.

. Models are being used for registration in Canada. AgDISP with FSCBG as front-end driver.

Milt Teske

. See report in Appendix B.

Brian Richardson

. See report in Appendix B.

Bill Steinke

. LI-COR unit. Used in four different orchard canopies ranging from relatively dense trees up to larger less dense trees and then up to trees that are hedged.

. Take home question - Where do we find the bulk of the foliage in the tree - varies with tree height.

. Pecan orchard study with Ellis Huddleston - using a standard orchard sprayer looking at what is captured by trees, what gets through the trees, what drifts.

Nicholas Woods

. See report in Appendix B.

. The Centre for Pesticide Application & Safety, The University of Queensland, Gatton College.

. Droplet size analysis, nozzle testing, formulation physical handling, computer modelling.

. Airblast spraying, aerial spraying.

. Larvacide for mosquito control, aerial spraying.

. Pesticide drift - very important in the Riverine environment.

. Have been doing modeling ULV pesticides with FSCBG.

. Noted that contributions from the committee would be welcome on alternative canopy models for FSCBG and simple drift prediction algorithms for incorporation with GPS technology.

Bruce Grim

. See report in Appendix B.

. USAF (Terry Biery) and Dugway Proving Ground have been cooperating in using the C-130 in decontamination of large areas.

. Helicopter buckets have not been tested for decontamination.

. Would like to incorporate GPS into FSCBG, especially looking at drift from aircraft.

Jim Rafferty

. See report in Appendix B.

. Model called SCIPUFF (Second Order Closure Integrated Puff Model) which models drift resulting from destruction of a nuclear, chemical, biological or other hazardous storage sites.

. What is starting condition? It could be anything described by puffs, i.e. line source.

. This model does gaseous dispersion and will handle particles in the near field.

. October 1996 the new version is coming out. It runs on Windows and Unix work station. (Model is available to US Gov't. agencies.)

Bill Jorden

- See report in Appendix B.
- Drift Sentry - Low cost, real time field sensor that alerts applicator to spray drift.
- Portable, battery operated. Alerts to the presence of spray drift by an audible and visible alarm and alerts pilot also. Senses both liquid and solid particles. Threshold of tolerance adjustable. Capable of giving a quantitative amount.
- Ten systems so far have been deployed and tested.
- Also developing a low-cost weather station proposal.
  - Low cost - Cost effective
  - Real time and off-line history outputs
  - Cellular access vs LAN
  - Stand alone - solar power
  - Phase I - Experimental stations for performance and cost analysis
  - Phase II - Prototype system fabrication
  - Replaces flagger with onsite remote sensor
- Target cost per production unit - <$5,000
- Smallest particle/drop the laser can see is 50 microns.
- Condensation is a big problem on the drift sensor - not sure what to say about condensation. Probably need to have them manufactured, sealed and used one time, then cleaned.

B. Round Table Discussion

Pat Skyler

- Asked for articles, photos, graphics for the FSCBG information letter which will be published in September.

Milt Teske

- Asked for any suggestions on the FSCBG model, especially when the new version comes out.
- Suggested that the FSCBG lite version may be a way to get reacquainted with the model after not using it for a period of time.

Nicholas Woods

- Suggested alternative canopies be looked at - other than trees/orchards.

- Integration with GPS.

- Collecting data in the vertical profile.

Brian Richardson

- Cooperative effort with FS in several areas.

- Under Brian Richardson: add dose-response i.e. "About 12 months ago started developing dose-response databases in connection with SpraySafe Manager".

- SpraySafe Manager - Decision Support System being incorporated into FSCBG. Primarily by New Zealand for herbicide applications. Developed because there was no way to link biological exposure with effects. Also needed an easier way to use FSCBG. Prototype has been developed. Environmental module also to predict buffer distance.

- Calculates productivity, will incorporate sensitivity study Milt Teske has done.

- NZ user group is currently evaluating the prototype.

- About 12 months ago started developing databases in connection with SpraySafe Manager.

- Glad to see discrete canopy option going into FSCBG.

- Will be involved in myco-herbicide development (i.e. the application of pathogens to control exotic weeds) in the next couple of years - will use FSCBG.

- Stand-alone FSCBG - hopes it will stay as a stand-alone. The other models developed that include FSCBG don't have all the capabilities of FSCBG by itself.

Parshall Bush

- Working with individual pulp and paper companies updating their manuals on how they do business on a day-to-day basis. Attempting to justify to companies why they need to do certain things (e.g., aircraft calibration, etc.).

- Hopes FSCBG will continue to stand alone and continue to have a support system - user group.

Harold Thistle

. A Program of Work was put together by Jack Barry and Harold in June. Included were the following items:

Seed orchard sanitation equipment project (e.g., use of vacuum and sweepers to clear orchard duff).

Spray drift mitigation, vegetation barriers to drift, drift in complex terrain.

Supporting pheromone application technology.

DGPS aircraft guidance - technology changing so fast may put on another demo with John Ghent in the East.

Ground sprayers for mosquito control - interest in a ground dispersion version of FSCBG.

Stationary tree sprayers - (high value trees) putting a spray nozzle on selected, high-value trees - Weyerhaeuser looking into putting up 1500 of them in their Washington, NC orchard.

Continue with the modeling activity - role of atmospheric stability as it influences deposition and drift.

Time-of-Day study to be pursued - probably next summer will look at stability vs deposition and drift. There is a study plan on this - it can be sent to anyone who is interested in making comments on it or in cooperating in the study.

Dupont interested in releasing a video showing smoke release.

Jack Barry

. Will be seeing more decision support systems that use FSCBG and related models as the base model or engine.

. Comment regarding stability, drop size, and drift. We need to search literature base - especially that at Dugway, Utah. FSCBG sensitivity has not been evaluated for stability. We need to do this.

. ULV logistically not feasible in California agriculture due to atomisers cost and resistance to change, but need to look at low volume for agriculture - we still need to come up with operational recommendations and then the applicators can use it if they wish.

Dave Whiteman

. VALDRIFT not suitable for rolling hills but more for distinct channels such as valleys.

Andrew Hewitt

. Mentioned completion of SDTF miscellaneous nozzle study which included over 70 different nozzle tips, encompassing all of the dozen or so major agricultural nozzle types (flat fan, deflector, simplex swirl, full cone, rotary cage, etc.). These included various nozzle manufacturers, designs and sizes.

. The SDTF is developing a droplet size database and model using these nozzles and diverse application and liquid physical property parameters.

Dave Valcore

. Four tank mixes covering the typical range of physical properties were tested in the miscellaneous nozzle study. Dave has invited the FS to contribute its dropsize database and drift studies where appropriate. (Note the database is in FSCBG and is available to SDTF via Milt Teske.)

. Malvern type and laser defraction units will overpredict the fines in a static test (no wind).

. In a wind tunnel where you are accelerating spray slightly with wind speed there is no bias.

. If you want accurate data with a Malvern (laser defraction), you need some wind behind it for typical agricultural sprays.

. All SDTF database info is available to Forest Service just need to go through the Freedom of Information act - need to apply through EPA. Questions - contact Dave.

Bill Steinke

. PMS company has stopped supporting their machine.

John Ghent

. GypsES in Northeast - developed in 1993 as a decision support system for aerial application.

. Also started getting into aircraft navigation - AgNav, Trimble and Satloc.

. Added spot imagery this month - FSCBG in a very user friendly way is integrated into GypsES.

. USDA-APHIS has expressed interest in becoming a GypsES partner; we will need to start looking at their needs. GypsES will be demonstrated to them Sept. 17 in Riverside.

- Demonstrated to Regional Forester staffs - Fire and Aviation, Recreation, and Law Enforcement - GypsES is very portable and that is what they need - using GPS as an example will enable accurate air drops.

- GypsES will also be demonstrated at SERG workshop in Ottawa this October and at NAAA/ASAE meeting in Reno this December.

Milt Teske

- Continuum Dynamics, Inc., the FSCBG, GypsES and SpraySafe Manager contractor, was recently awarded a Small Business Innovation Research (SBIR), Program Phase I contract from the US Department of Agriculture. This effort will seek to begin design on the concept of a "smart bucket" for fire fighting. Currently, the speed and height of the helicopter control the coverage level of retardant on the ground. Under fire conditions it is often difficult or unsafe to achieve the desired height and speed. With the smart bucket design concept, system controls would adjust the release of the retardant material to account for changes in height and speed, producing better and more accurate coverage. The intention here is to more quickly control the spreading fire, use less retardant material with fewer transits to refill, with less danger to the helicopter pilot, crew and aircraft. If the research is successful, and moves into the prototype design and testing stage, the ability to improve use of aerial buckets in fire management.

- CDI has worked in the past with the Intermountain Research Station personnel in Missoula (Chuck George and Greg Johnson), cooperating with the US Army and the USDA Forest Service (Davis office) to measuring the influence of large helicopter wakes on lateral fire spread and dispersion of contaminants such as dust and pesticides.

- More information about smart buckets may be obtained from Andy Kaufman (CDI) at (609) 734-9282.

John Ghent

- Trimble - currently no technical support.

- We need to sit down with Milt Teske to discuss bringing some of the enhancements of FSCBG 5.0 into GypsES.

Jack Barry

- Discussion has been done regarding connecting FSCBG with environmental fate models - interest has been shown - Milt has talked with paper industry in Oregon regarding this - possible funding is forthcoming.

- The Forest Service will present posters on GypsES and SpraySafe Manager at the national meeting of the Society of American Foresters in Albuquerque, NM, November 9-13, 1996.

- July 25th is the due date for abstracts for NAAA/ASAE Reno meeting. NAAA needs to know about GypsES - meeting will be December 9, 1996. This would be a good way to communicate the system and introduce it to them - John Ghent is on the program to discuss GypsES. Jack Barry will present a paper on orchard spraying.

Terry Biery

- Regarding expert system for C130 - FSCBG not incorporated into.

- Decontamination - need to get adequate decontamination coverage - can't have hot spots, misses.

- Oil spill dispersion work, barrier treatment, malaria ULV larvacide work.

Dave Davies

- Commented that Drone helicopters are being used in Japan.

- ASAS-RF system - goes on 172 - giving real-time temperature profiles.

- Updating to AIMMS system this year - looking to be able to give real-time stability.

- Trimflight and AGNAV systems on aircraft.

Bill Steinke

- Ken Giles project has been commercially licensed to CAPSTAN - Trade name is SYNCRO system.

- Flow rate can be changed keeping same droplet size and vise versa.

- Don't think anything has been tested aerially in the field yet.

- SBR funding was received for Phase I.

Bruce Grim

- Feels it is absolutely essential that this committee continue - the exchange of ideas is very important.

Dave Valcore

. Coalition on Drift Minimization - working on educating applicators. Committee meets in Washington, DC. Dave Thomas represents the Forest Service.

. Task force still needs to get with Forest Service to pull in data bases on drift application. Commitment from task force to do this - need to make this happen - maybe through Andrew Hewitt? Milt Teske? - Maybe a format that would help get us started. (Jack Barry will coordinate with Dave.)

Jim Rafferty

. Strongly supports keeping FSCBG as a stand alone version.

Jack Barry

. FSCBG has evolved into a mature model. Its future will be to support DSS and other versions of the model e.g., AgDrift, SpraySafe Manager, and Spray Advisor.

. Supports this also - need a strong broad-base user group. Most of the 180 user group members are outside the FS.

Dave Esterly

. SDTF moving into a phase where they didn't expect to be - that is outreach and education.

. Adm. and tech. committee feels that since they collected all this data that now it needs to be made available to the users and public - moving in that direction - through drift correlation.

. All field studies are done - atomization work done - now a matter of getting data together and reports written.

. How to do a drift study - one report that may be of interest to the agency - may help to compare data.

. AgDrift (AgDISP in disguise) - very helpful in designing their studies.

. EPA has a web site where you can download models - looking into putting AgDrift on this web site.

. California version will be available about this time next year - this will be a model that will be on the web site.

. Need long-term support of the model - funding is a problem.

. Task force has been working to educate the regulators to look at the application in a more critical mode.

. Once a model reaches EPA no changes made - it remains static.

. NAAA has asked SDTF to make a training version of the model - don't know who would pay for.

. Appreciates the Forest Service generosity in giving SDTF the AgDISP model.

Bill Jorden

. Important to maintain FSCBG - it is the link to all these other models. It is the corporate memory.

. What about National Science Foundation funding?

. Applicators reduce drift - regulators don't reduce drift - applicators are told to reduce it but not how.

Harry Hubbard

. This committee is interesting for research PAS - we will continue to update our spray application equipment, work with the gypsy moth virus.

. Formulations are constantly changing and we constantly need to keep checking them before they go out to the field.

Dave Esterly

. FSCBG is the engine to a lot of other needs.

Jack Barry

. Really appreciate all the interest and fine support of this committee.

. Indicated this steering committee would continue - whether it will be a major committee for the Forest Service is unknown - Harold Thistle will chair next meeting.

. Next meeting will be in Minneapolis, August 10-14, 1997.

. Application technology needs identified by committee include:

Time-of-Day study - meteorology/stability, how it influences deposition and drift, and what are the limits
Vegetation barrier such as shelter belts to reduce drift (ground and aerial)

Validating the LiCor model to describe canopies
In the long term - get the models in the cockpit (real-time)
Application training
Add to FSCBG and AgDrift drop size database.

. Invite NAAREF (National Agricultural Aviation Research and Education Foundation) - an arm of NAAA - to next meeting

. Final version of bibliography will be finalized by end of 1996.

. Exotic weed control - FHTET-Davis provided funding to Utah State University (involves formulation and aerial application of a fungal agent to control Dyer's woad).

. CP nozzles - becoming very widely used - Jules Picot and SDTF have independently generated CP nozzle atomization data. These data would provide a valuable addition to the FSCBG database.

. Will present a paper on orchard spraying at NAAA/ASAE meeting in Reno, December 9, 1996.

III. RECOMMENDATIONS/TECHNOLOGY NEEDS

A. Recommendations

1. Continue pursuing use of FSCBG to support decision support systems such as New Zealand's SpraySafe Manager and GypsES Spray Advisor.

2. Maintain the integrity of FSCBG as a stand alone, genetically pure model.

3. Maintain and support FSCBG user group.

B. Technology Needs

1. Test and demonstrate with cooperators FSCBG version Real-Time - a capability to monitor movement of spray cloud in real time while aircraft is in flight and spraying.

2. Connect FSCBG to environmental fate and impact models and do so in partnerships to support this effort.

3. Conduct with cooperators field tests to evaluate tree barriers, e.g. shelter belts, to contain spray drift by scavenging droplets.

4. Continue validation of models and DSS as data become available from cooperators and other sources, especially projects involving

aerial application of biologicals to control exotic defoliators in urban areas.

5. Conduct field trials of Li Cor instrument to characterize canopy structure.

6. Conduct literature search at US Army Library, Dugway, Utah of drift studies to support investigations of stability effects on spray drift.

7. Add the SDTF "drop kick" spray atomization sub-routine to FSCBG.

IV. SUMMARY

The Sixth Meeting of the National Spray Model and Application Technology Steering Committee was held at Phoenix, AZ on July 17-18, 1996. Members reported on field testing and projects over the past year and discussed technology development needs concerning application technology and modeling drift, spray behavior, and environmental accountancy. The committee noted the support of management in encouraging and funding projects through technology development and other sources; the progress that has been made in advancing the models over the past year; and absolute need to maintain the integrity of the FSCBG model as a stand alone system. The participation and other support of our colleagues in industries, academia, and other agencies are recognized and appreciated, for without their involvement the utility of this committee would be crippled. It is the chair's continued vision and I hope that of the membership that this committee might serve an increasing role of coordinating application technology research and development nationally and internationally. My personal thanks to each of you in helping to develop, enhance, and transfer this technology. Our next meeting will be held at Minneapolis, MN the week of August 10-14, 1997 during the International Meeting of the American Society of Agricultural Engineers. Please mark your calendar as we are looking forward to your continued support and participation.

APPENDICES

A. Meeting Call Letter and Agenda

B. Member Reports

C. List of Committee Members / Past Attendees / Others

Appendix A

Meeting Call Letter and Agenda

United States Department of Agriculture | Forest Service | FHTET - Davis Washington Office | 2121 C Second Street
Davis, CA 95616
PH (916) 757-8342
FAX (916) 757-8383

File Code: 2150 Date: May 30, 1996

Subject: National Spray Model and Application Technology Steering Committee Meeting

To: Colleagues

Meeting Call Letter

The National Spray Model and Application Technology Steering Committee will meet in Phoenix, AZ during the International Meeting of the American Society of Agricultural Engineers. We have two sessions as listed:

Dates/Times: July 17 (Wednesday) 1700 to 1900 and continuing
July 18 (Thursday) 0800 to 1200

Place: Phoenix Civic Plaza
Flagstaff Four, North Building

The purpose of the meeting is to:

Provide an opportunity for participants to informally report on their spray model and pesticide application technology activities in agriculture, forestry, and insect vector control;

Identify technology needs and encourage partnerships and cooperative projects; and

Obtain participant's comments on future need, opportunities, charter, sponsorship, and leadership of this committee.

In the conduct of prior meetings we have used the "round robin" method of providing each participant time (about 10 minutes) to summarize his/her activities. Handouts are suggested as an efficient way to share additional information and as a resource for me in reporting the meeting. Projectors (overhead and 35mm) will be available during the Wednesday session only.

The purpose of the steering committee is:

1. To exchange national and international information on spray model and application technology development activities;

2. To support the advancement of technology for the safe, economic, efficacious application of biorational and other pesticides;

3. To identify model and application technology needs; and

4. To facilitate cooperation, partnerships, and economies.

Since the committee's initial meeting at Atlanta, GA in 1990 participants have expressed their support of this forum and the opportunity to informally share information and coordinate activities with their colleagues. In recent years we have been fortunate to have participants from academia, industry and governments, including representation from Canada, New Zealand, and Australia. Our last meeting was in Kansas City, MO, June 22, 1994, with notes reported in the committee's fifth report (FPM 94-15). If you would like a copy of this report please give me a call. Enclosed is a draft agenda for your review and comment.

/s/John W. Barry
JOHN W. BARRY
Chair

Encl. Agenda

cc: Susan Buntjer, ASAE

draft
May 30, 1996

Agenda

National Spray Model and Application Technology Steering Committee

Phoenix, AZ

17-18 July 1996

Introduction

- Purpose of meeting
- Introductions
- Protocols
- Notes and report
- Summary of the 1994 committee meeting

Discussions

- Individual informal reports
- Spray Drift Task Force
- Coalition on Drift Minimization
- Future of the Committee
- Recommendations & Resolutions

Conclusions

- Restate meeting purpose
- Summary of meeting
- Follow up actions

Appendix B

Member Reports

Bill Jordan

Jim Rafferty

Bob Mickle

Bruce Grim

Milt Teske

Dave Davies

Jack Barry

Nick Woods

Dave Whiteman

Dave Esterly

Brian Richardson

Bill Jordan
B.W. Jorden & Co., Inc.

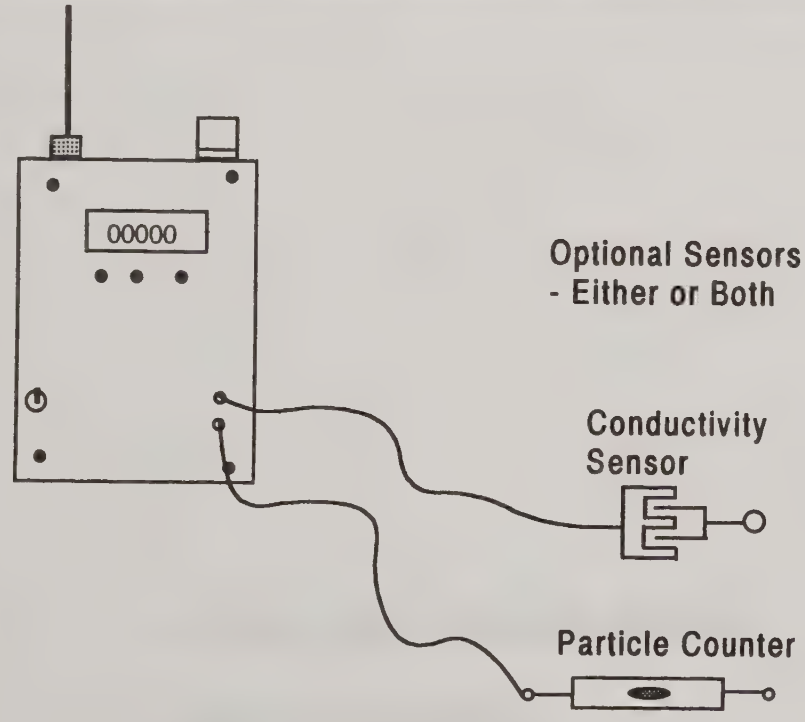
Drift Control Related Activities at B. W. Jorden & Co., Inc.

- Drift Sentry
- Rotary Sensors
- Low Cost Weather Station

Bwj
15 JULY '96

BASIC SENTRY

BWJ Inc.



Basic Drift Sensor

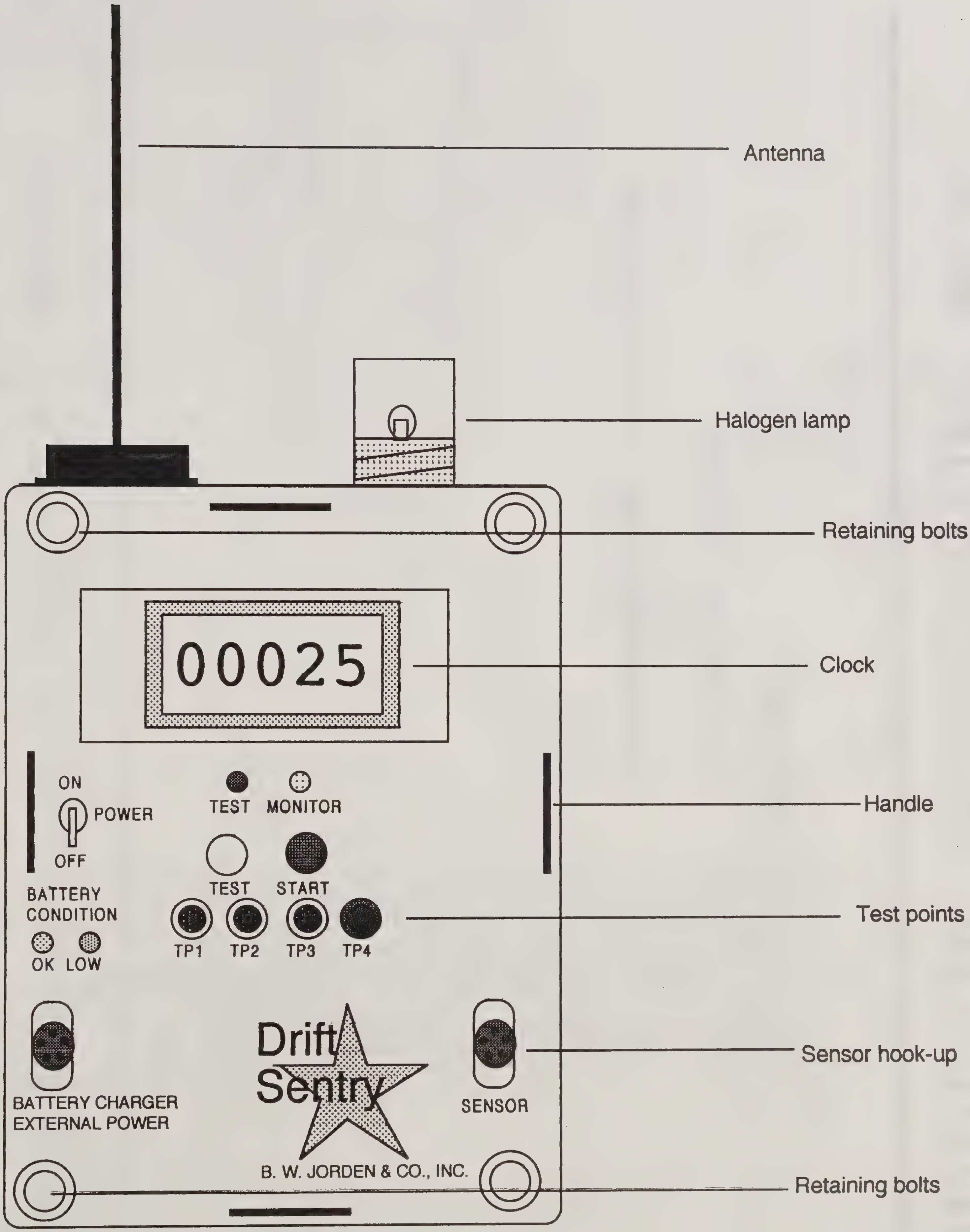
- Alerts applicators to Spray drift.
- Gives an audio and visual alarm, plus radios the pilot on his VHF radio.

Conductivity Sensor

- Senses liquid particles only (conductive).
- Threshold of tolerance adjustable.
- Inexpensive -- sensor can be disposed of with HAZMAT or cleaned and reused.

Particle Counter

- Senses both liquid and solid particulates.
- Threshold of tolerance adjustable.
- Capable of giving a quantitive amount.


Antenna
Halogen lamp
Retaining bolts
00025
Clock
ON
POWER
OFF
TEST
MONITOR
Handle
TEST
START
BATTERY CONDITION
OK LOW
TP1 TP2 TP3 TP4
Test points
Drift Sentry
BATTERY CHARGER EXTERNAL POWER
SENSOR
Sensor hook-up
B. W. JORDEN & CO., INC.
Retaining bolts

Dwg 10156

CONDUCTIVITY SENSOR

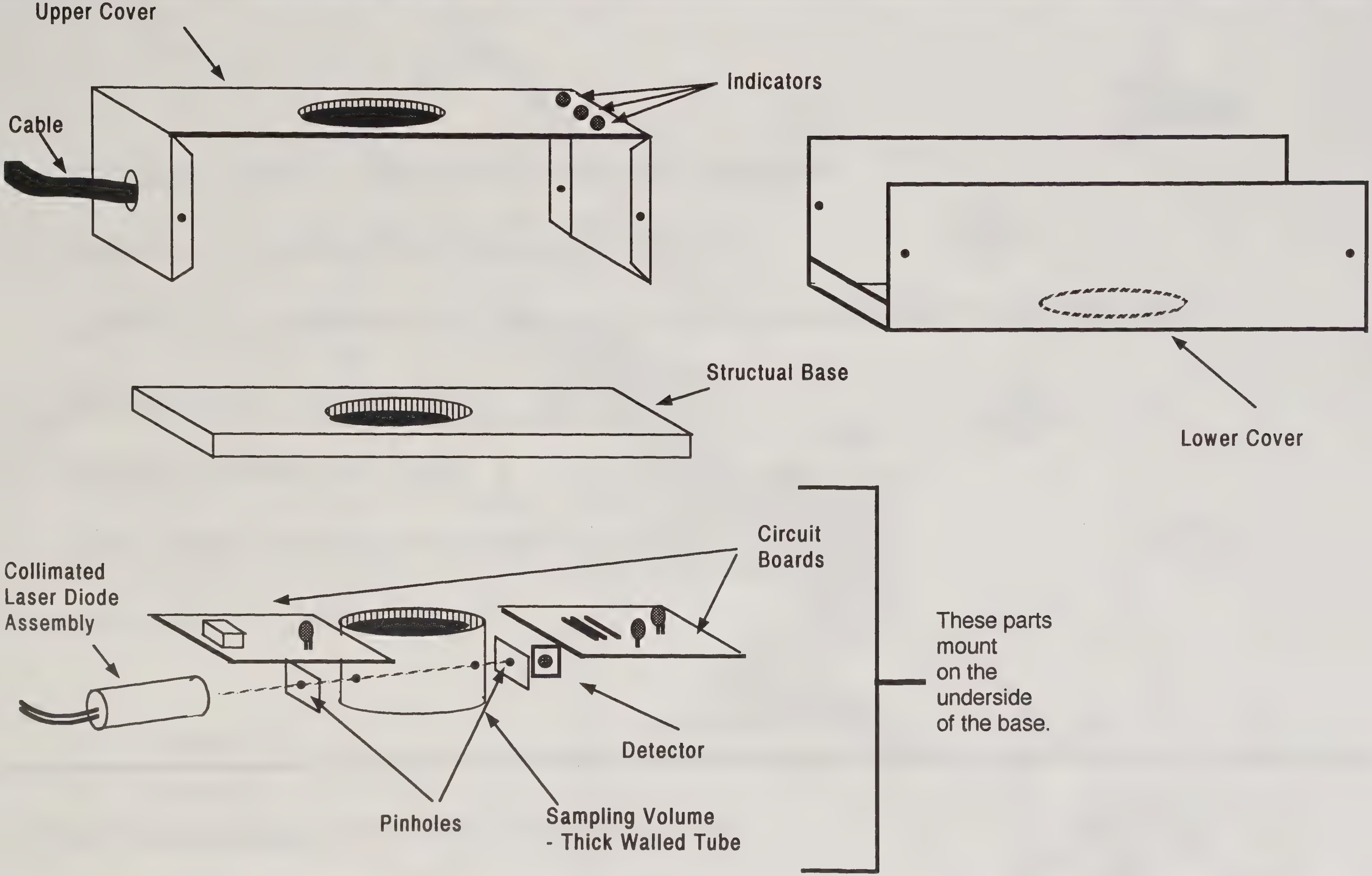
BWJ Inc.

OPTIONS:

- Printed Circuit Board 10 Mil X 10 Mil
- Etched Copper-Nickel on Kapton 1 Mil X 1 Mil (500 ft. Total)

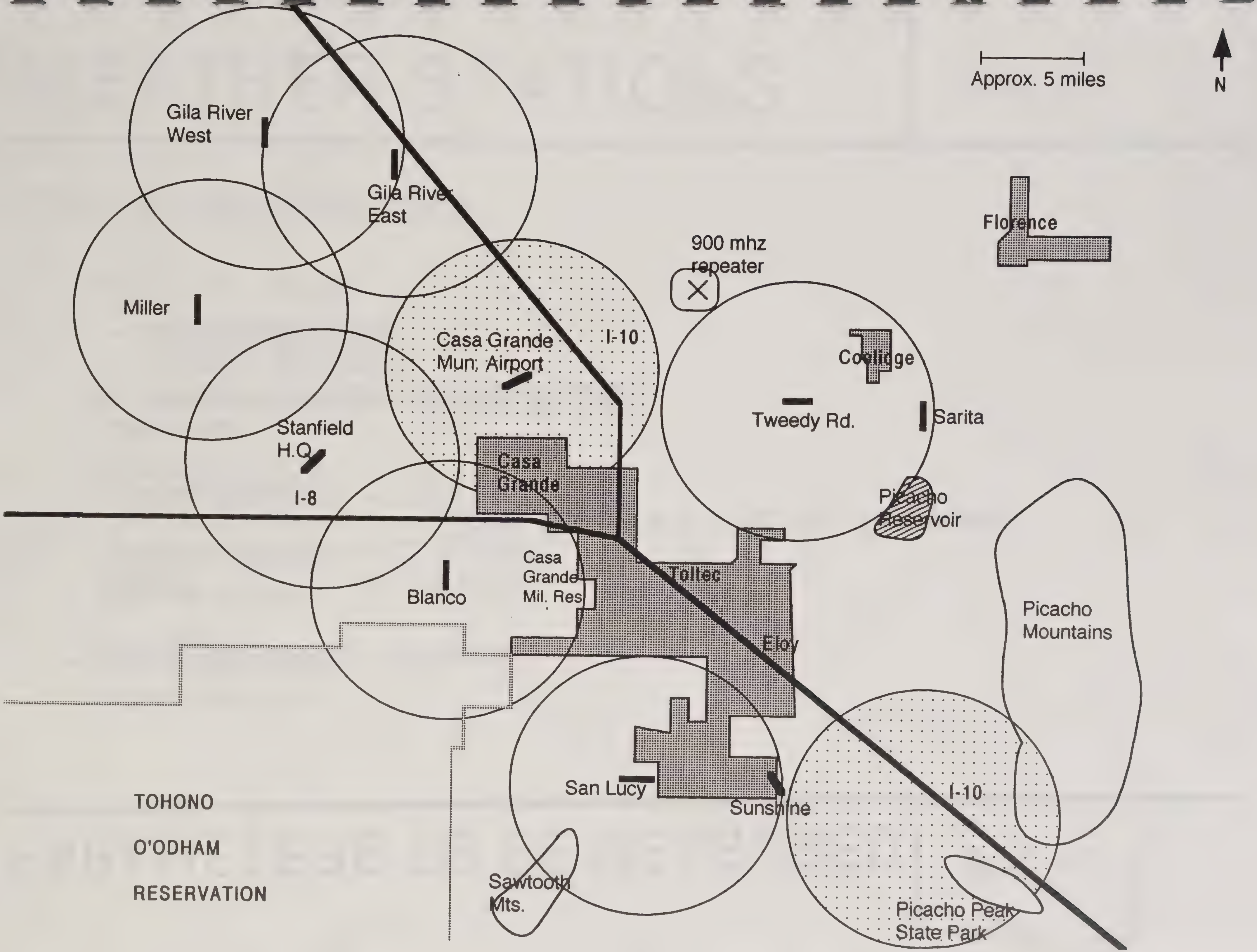
LOW COST PARTICLE COUNTER

BWJ Inc.



LOW COST WEATHER STATION PROPOSAL | BWJ Inc.

- Low Cost -- Cost Effective
- Real Time and Off Line History Outputs
- Cellular Access vs. LAN
- Stand-Alone -- Solar Power
- Phase I -- Experimental Stations for Performance and Cost Analysis
- Phase II -- Prototype System Fabrication
- Replaces Flagger with On-site Remote Sensors



Approx. 5 miles
N
Gila River West
Gila River East
Miller
Casa Grande Mun. Airport
I-10
Stanfield H.Q.
I-8
Casa Grande
Blanco
Casa Grande Mil. Res.
900 mhz repeater
Tweedy Rd.
Coolidge
Sarita
Florence
Picacho Reservoir
Tollec
Eloy
Picacho Mountains
San Lucy
Sunshine
I-10
Sawtooth Mts.
Picacho Peak State Park
TOHONO
O'ODHAM
RESERVATION

PARAMETERS TO BE MEASURED

- Issue: On-line vs. Historical
- Highest Priority
  - Wind Velocity
  - Wind Direction

  Compute a "Stability" Parameter
- Additional
  - Temperature and Vertical Gradient
  - Relative Humidity
  - Rainfall/Moisture

WEATHER STATIONS

BWJ Inc.

COST CONSIDERATIONS

- Target Cost < $5,000

  System $50,000

- Ten Year Amortization -- $5,000 per year

- <u>Cost Avoidance</u>

Typical Lawsuit	$10,000
Aborted Mission	$500
Repeated Application	$5,000+
Fines	$50 - $10,000

- <u>Other Factors</u>

  Pilot Decertification
  Public Relations

PARAMETERS TO BE MEASURED!

Jim Rafferty
US Army Dugway Proving Ground

LARGE AREA DECONTAMINATION (LAD)

OBJECTIVE: To utilize existing C-130 Aerial Spray System capabilities and Helicopter Bucket Drop techniques for Large Area Decontamination of Chemical/Biological hazards for military operations and civilian disaster control.

INTRODUCTION: Military staging areas, seaports, airfields, battlefields, access routes, etc. are all vulnerable to chemical contamination by enemy missile attacks. An effective means of partial or total decontamination could prove vital for continued effective operations in these areas where decontamination by ground methods (truck delivery) is in many cases severely limited by access to water and on the spot decontaminant supplies. The civilian sector has for many years been effectively using aerial spray techniques to handle large area outbreaks of detrimental insect pests, as well as, controlling forest fires using spray and bucket drop techniques; in addition, large oil spills are now being controlled with aerial spray techniques. Technology transfer between the US Department of Agriculture, US Air Force, and US Army over the past 25 years has developed sophisticated computer modeling to aid in aerial spray applications. The 910 AG/Aerial Spray Group, Youngstown, OH under the guidance of Dr. Tiery Biery has many years of experience spraying insecticides and herbicides using 2000 gal capacity spray systems mounted in C-130 aircraft. This spray system is capable of generating very fine ultra low volume sprays for insecticide applications, but is also capable of generating large droplets and heavy uniform coverage over many acres.

Using the Forest Service-Cramer-Barry-Grim (FSCBG) computer model, swath widths and flow rates can be taylored for almost any application. Dr. Biery's group is now investigating use of geosynchronous positional satellite systems to guide the aircraft within 1 or 2 meters of the intended ideal flight path, this will insure very uniform decontaminant coverage over a large area. A small scale feasibility test run on 2 Oct 94 has shown great promise for using this C-130 system to cover large areas with very little 'untouched' area (see sample card).

In addition to the C-130 system, US Army Dugway Proving Ground has been working on a joint effort with the USDA Forest Service to model wake effects from heavy helicopters carrying 3000 gal fire retardent buckets. These buckets could have major impact on hazard scenarios involving heavy spills of toxic chemicals or Chem/Bio agents. The drop pattern for these buckets has been well documented by the Forest Service and they would be very useful for decontaminating heavy concentrations in smaller areas (tens of meters X hundreds of meters).

LONG TERM PROGRAM GOALS:

* Demonstrate that the operational C-130 spray system is capable of decontaminating large areas with very high fractional coverage

* Develop and test the capability of using fire retardent bucket drops from large helicopters on several operational scenarios involving heavy toxic spills

* Develop operational guidelines for carrying out large area decon operations

* Develop proper decontaminant recipes to optimize air decon operations (dye added for visual confirmation of coverage)

* Integrate GPS techniques into decon spray delivery for pinpoint accuracy

* Develop aircrew guidelines for safe flight operations in a toxic environment (this is a fallout of Cargo Aircraft Decontamination Studies presently being done for AMC)

Rafferty

June '96 Volume 1.3

HASCAL HORIZONS

Hazard Assessment and Consequence Analysis

HPAC 1.0 Released

In May we released the HPAC 1.0 CDROM. This CDROM packages HASCAL 1.0a together with a new sample project, a complete set of SCIPUFF-readable high-resolution maps, and some support software for converting AFGWC's AFDIS weather data into a SCIPUFF-readable format. Although HASCAL cannot be run directly from the CDROM, it is possible to use the high-resolution maps from the CDROM instead of installing them on your hard drive. The CDROM also includes an image of each of the floppy disks used in installing HASCAL from floppy disks.

HASCAL 1.0a Released

HASCAL 1.0a was released in February of 1996. It represents the first operational release of an integrated Biological Facility (BFAC) source term capability associated with the DNA Counter Proliferation ACTD. It also includes the stand-alone Nuclear Facility (NFAC) source and effects version of HASCAL, similar to HASCAL 0.6. HASCAL 1.0a represents a significant departure from HASCAL 0.6 in terms of appearance and capability and is an indicator of what lies in the future for HASCAL. The integrated BFAC source term model is the first example of a tighter coupling between source term generation models and SCIPUFF. In a future release, BFAC will be joined by an integrated NFAC model as well as Chemical Facility (CFAC), Nuclear Weapon (NWPN), and Chem/Bio Weapon (CBWPN) integrated source term models. HASCAL now presents a more consistent user interface across all source models and more easily allows users to specify multiple source terms (from more than one model) in a single calculation.

HPAC 2.0

In October 96, HPAC 2.0 is scheduled for release which will contain more user friendly source models for nuclear, biological, and chemical facilities and nuclear, biological, and chemical weapons. A broader database of historical weather will also be accessible for any case. Observational and prognostic weather model data input will be presented in a much more user friendly format. HPAC 2.0 will be released with the executable code, its associated user's guide, technical documentation and validation document.

HPAC Transport Modeling

The Second-order Closure, Integrated PUFF model (SCIPUFF) is the transport code used in HPAC. There are two basic aspects to the SCIPUFF model. First, the numerical technique employed to solve the dispersion model equations is the Gaussian puff method in which a collection of three-dimensional puffs of arbitrary orientation is used to represent an arbitrary time-dependent concentration field. Second, the turbulent diffusion parameterization used in SCIPUFF is based on the second-order turbulence closure theories of Donaldson (1973) and Lewellen (1977), providing a direct connection between measurable velocity statistics and the predicted dispersion rates.

The Lagrangian puff methodology affords a number of advantages for atmospheric dispersion applications from localized sources. The Lagrangian Scheme avoids the artificial diffusion problems inherent in any Eulerian advection scheme, and allows an accurate treatment of the wide range of length scales as a plume or cloud grows from a small source size and spreads onto larger atmospheric scales. This range may extend from a few meters up to continental or global scales of thousands of kilometers. In addition, the puff method provides a very robust prediction under coarse resolution conditions, giving a flexible model for rapid assessment when detailed results are not required. The model is highly efficient for multiscale dispersion problems, since puffs can be merged as they grow and resolution is therefore adapted to each stage of the diffusion process.

The generality of the turbulence closure relations provides a dispersion representation for arbitrary conditions. Empirical models based on specific dispersion data are limited in their range of application, but the fundamental relationship between the turbulent diffusion and the velocity fluctuation statistics is applicable for a much wider range. Our understanding of the daytime planetary boundary layer velocity fluctuations provides reliable input for the second-order closure description of dispersion for these conditions. For larger scales and upper atmosphere stable conditions, the turbulence description is based on climatological information, but the closure framework is in place to accept improvement as our understanding of these regimes improves. The closure model has been applied on local scales up to 50km range (Sykes et al., 1988) and also on continental scales up to 3000km range (Sykes et al., 1993).

The second-order closure model also provides the probabilistic feature of SCIPUFF through the prediction of the concentration fluctuation variance. In addition to giving a mean value for the concentration field, SCIPUFF provides a quantitative value for the random variation in the concentration value due to the stochastic nature of the turbulent diffusion process. This uncertainty estimate is used to provide a probabilistic description of the dispersion result, and gives a quantitative characterization of the reliability of the prediction. For many dispersion calculations, the prediction is inherently uncertain due to a lack of detailed knowledge of the wind field and a probabilistic description is the only meaningful approach.

Points of Contact

Program: DNA/WEL, Weapons Effects

LTC A.J. Kuehn LtCol J. Hodge,
MAJ D. Myers, Maj Tom Smith
6801 Telegraph Road
Alexandria, VA 22310-3398
(703) 325-6106 FAX: (703) 325-0398
dsn 221-7143

Newsletter Coordinator , Rita Cooper
e-mail: rcooper@logicon.com

SCIPUFF
SECOND-ORDER CLOSURE INTEGRATED PUFF MODEL

Some Features Of Interest To Spray Modelers:

- Performs well in short range and long range (drift) applications.

- Could represent dispersion in complex flow environments such as complex terrain and within plant canopies.

- Uses multiple meteorological observations that describe the vertical and horizontal structure of the atmosphere through time.

- Produces mean and probabilistic dispersion results.

Bob Mickle
Environment Canada

SCIPUFF
SECOND-ORDER CLOSURE INTEGRATED PU[illegible]F M[illegible]

Of Interest To Spray Modelers:

- [illegible]

- [illegible]ent dispersion in complex flow environ[illegible] such as complex terrain and within plant [illegible]

- [illegible] meteorological observations that [illegible] the vertical and horizontal structure of the [illegible] through time.

- [illegible] mean and probabilistic dispersion results.

****
Bob Mickle
4905 Dufferin St
Downsview, Ont
Canada
M3H 5T4

Voice: 416 739 4851
Fax: 416 739 5708
****

Hi Jack:

As Promised:

For FSCBG Newsletter:

For FSCBG Newsletter:

FSCBG Used to Optimize Space Spraying for Mosquito Control

At the American Mosquito Control Association Meeting in Norfolk, Virginia, a symposium entitled "Direct Control of Adult Mosquitoes/ State-of-the-Art Technologies" was held. A paper presented by R. Mickle, Environment Canada on the "Practical Uses of FSCBG" utilized the AGDISP component (near wake code) to predict the droplet distribution in the drift cloud at various distances downwind of the flight line. Typical drop size distributions employed in mosquito space spraying using Malathion were investigated for a range of meteorological conditions. Deposit densities for drops greater than 200 microns were investigated for potential surface damage. Drift distributions and mosquito collection efficiencies were combined to develop toxic dose profiles out to 1 mile for varying spray strategies . In particular, it was shown that enhanced contact probability in the near field could be obtained by multiple passes on the upwind spray line.

For Notes from Phoenix Meeting:

Work in 95/96

1.The model was used to optimize spray strategies for adult mosquito control. Results were presented at the American Mosquito Control Association Meeting in Norfolk, Virginia. Data were presented as probability contours for a toxic dose in the drift cloud for varying spray strategies.

2.An operational spray in complex terrain was evaluated to compare the accuracy of GIS digital maps/ DGPS guidance with an onboard radar altimeter to estimate whether the GIS/DGPS system could be used to extract aircraft height from the flight log as input for spray fate modelling using FSCBG. Generally, the two heights compared within 5m over complex terrain with height variations greater than 200m. Coupled with flow and onboard met sampling, these data could be used to predict the spray fate from operational sprays.

Future Direction:

1. Use of FSCBG for Spray Planning:

Extensive model/ measurement comparisons has shown the capability of FSCBG to accurately predict the fate of pesticides from aerial spraying. In Canada, FSCBG (AGDISP) continues to be used to develop buffer zones as mitigative measures for environmentally sensitive areas. Work is continuing to incorporate FSCBG deposit predictions as input to Expert Systems (SpraySafe Manager, GYPSeS) which employ dose-response relations to optimize spray strategies.

1.It would be useful if these systems could employ a loop-back mechanism to optimize the spray (say on-target deposit) for varying spray strategies given a set of constraints for spray conditions. In particular, several spray strategies employ small droplet spraying where flight line offset on the upwind side of a block is important to ensuring coverage on the upwind

side of the block. Often, multiple spraying of the upwind side is required in order to obtain adequate coverage for pest control. With this multiple spraying, track spacing will not remain uniform across the remainder of the block. It would be useful for the model to be able to optimize the spray scenario for say uniform deposit at a level which minimizes pesticide use and yet ensures adequate deposit for pest control. The algorithm should be relatively simple and quick as it requires only a process of overlaying the result from a single spray run in the optimization process. It may also be found that downwind spray lines could be eliminated (or spayed at reduced rates) due to the build up from the upwind sprays. If so this could have beneficial effects on reducing the input of pesticides into environmentally sensitive areas. There should also be some presentation of the effects of varying spray windows on the end result (ie range of tolerances of met or aircraft height).

2.Effort should be put into incorporating these strategies into drift cloud management as well. Expert systems useful for mosquito control is a case in point where collection efficiencies coupled to drop size/densities within in a cloud are important in optimizing spray strategies. Effort should be made to produce contour diagrams of say toxic dose for varying heights as a function of distance from the first upwind spray line (similar to deposit contours).

Post Spray Analysis:

Reality indicates that spray programs don't have parallel spray lines, uniform flows and aircraft heights. Post spray modelling requires the ability to incorporate these variations into an accurate prediction of the pesticide fate. Areas requiring respray could be based upon dose-response coupled with the predicted deposit based upon the actual spray.

1.Model should be capable of handling input from an actual spray program (non-parallel lines, non-uniform flows and aircraft height, varying meteorology) to predict spray fate. At the very least, the model should take the input data and based upon known sensitivity effects combine the data to show the range of deposits that may have occurred during the spray program. These data could then be looped back through an Expert System to develop an appropriate strategy for respraying. It is important that this process is automatic with little input from the user. If this model is to achieve popularity with the spray industry, it requires automation and results that can be presented quickly and are relevant for decision-making.

Use of FSCBG in Real Time:

Given the capability of FSCBG to predict spray fate, effort should be made to expand FSCBG/RT to be used as the basis for an expert/feed back system in aerial guidance systems. FSCBG/RT should be validated for deposit in the far-field to see if it is an appropriate model. Perhaps a look-up table based upon characterization runs for the given aircraft/ nozzle arrangement would be more accurate and would be relevant to the near as well as the far field. From model runs, it is apparent that simple track spacing is not necessarily the optimum method for aerial spraying. It is important to marry the predictive capabilities of models with the guidance capabilities of DGPS.

Bob

Bruce Grim
US Army Dugway Proving Ground

C-130 2000 GAL MODULAR AERIAL SPRAY SYSTEM (MASS) BEING USED FOR LARGE AREA DECONTAMINATION (LAD) DEMONSTRATION AT THE UTAH TEST AND TRAINING RANGE IN OCT 1995

THIS SYSTEM HAS BEEN DEMONSTRATED TO HAVE THE POTENTIAL TO APPLY DECONTAMINANT WITH GREAT PRECISION AND UNIFORMITY OVER LARGE AREAS SUCH AS:

* ROADWAYS AND AREAS CONTAMINATED FOR TERRAIN DENIAL
* RUNWAYS AND TAXIWAYS
* INTERCEPTED THEATER MISSILE IMPACT AREAS
* SEAPORTS AND STAGING AREAS
* CIVILIAN OR MILITARY TOXIC SPILLS

FOR MORE INFORMATION CONTACT:

LT COL TERRY BIERY
910 AIRLIFT WING
YOUNGSTOWN-WARREN RGL APRT
ARS OH 44473-0910
DSN 346-1178 FAX: 1161
COM: (216) 392-1178

BRUCE GRIM
STEDP-JCP
U.S. ARMY DPG
DUGWAY UT 84022
DSN 789-3371 FAX: 2397
COM: (801) 831-3371

Milt Teske
Continuum Dynamics, Inc.

Met Teske overheads

USDA Forest Service
Aerial Spray Models
AGDISP and FSCBG

1996 Model Status Report

Milton E. Teske
Continuum Dynamics, Inc.

National Spray Model
and Application Technology
Steering Committee

Phoenix, Arizona
17-18 July 1996

Status of the Models

FSCBG

5.0 to be released Fall 1996

New Features:

- Discrete canopy option
- Extensive additional graphics
- Dose-response database
- Decision support module (SpraySafe Manager)
- Sensitivity module
- Canopy library

AGDISP

6.1 Maturity

User Group Count: 47 AGDISP and 176 FSCBG

Three training sessions:

Toronto, Ontario	28 February - 1 March 1995
Edmonton, Alberta	9-10 March 1995
Quebec City, Quebec	19 April 1995 (in French)

FSCBG User Group

176 members

Newsletter #6 - September 1995

Breakdown by country:

Australia	4
Canada	80
Chile	1
England	2
New Zealand	16
USA	73
USDA FS	19 (11%)

Validation Reports

1990 C-130 Spray Trials		FPM 93-10
1988 Davis Spray Characterization Trials		FPM 93-12
1991 Davis Virus Spray Trials		FPM 94-2
1972 C-47 Spray Deposition Study	1:	FPM 94-11
	2:	FPM 95-8
	3:	FPM 95-16
1974 Rennic Creek Spray Trials		FPM 94-12
1992 Utah Gypsy Moth Eradication		FPM 94-13
1994 Helicopter Rotor Wash Effects (Fire)		FPM 95-7
1991-1993 Utah Drift Studies		FPM 95-18
1985, 1994 Hennigan Almond Orchards	1:	FPM 96-3
	2:	FHTET 96-03
	3:	FHTET 96-04
1980 Withlacoochee Seed Orchard		FHTET 96-05
1992 Charter Orchard Peach Twig Borer		FHTET 96-11

New FSCBG Features

FSCBG/RT real time subroutines

FSCBG/D demonstration system

One-on-one training notes

Implementation into SpraySafe Manager (preliminary)

Extended sensitivity study for decision support

Other Topics

Spray Drift Task Force - AgDRIFT and DROPKICK

U. S. Air Force Fuel Jettisoning - FJSIM

FSCBG/GypsES implementation as Spray Advisor

Complete decision support work (SpraySafe Manager)

Add cost-benefit module

Gaussian model sensitivity

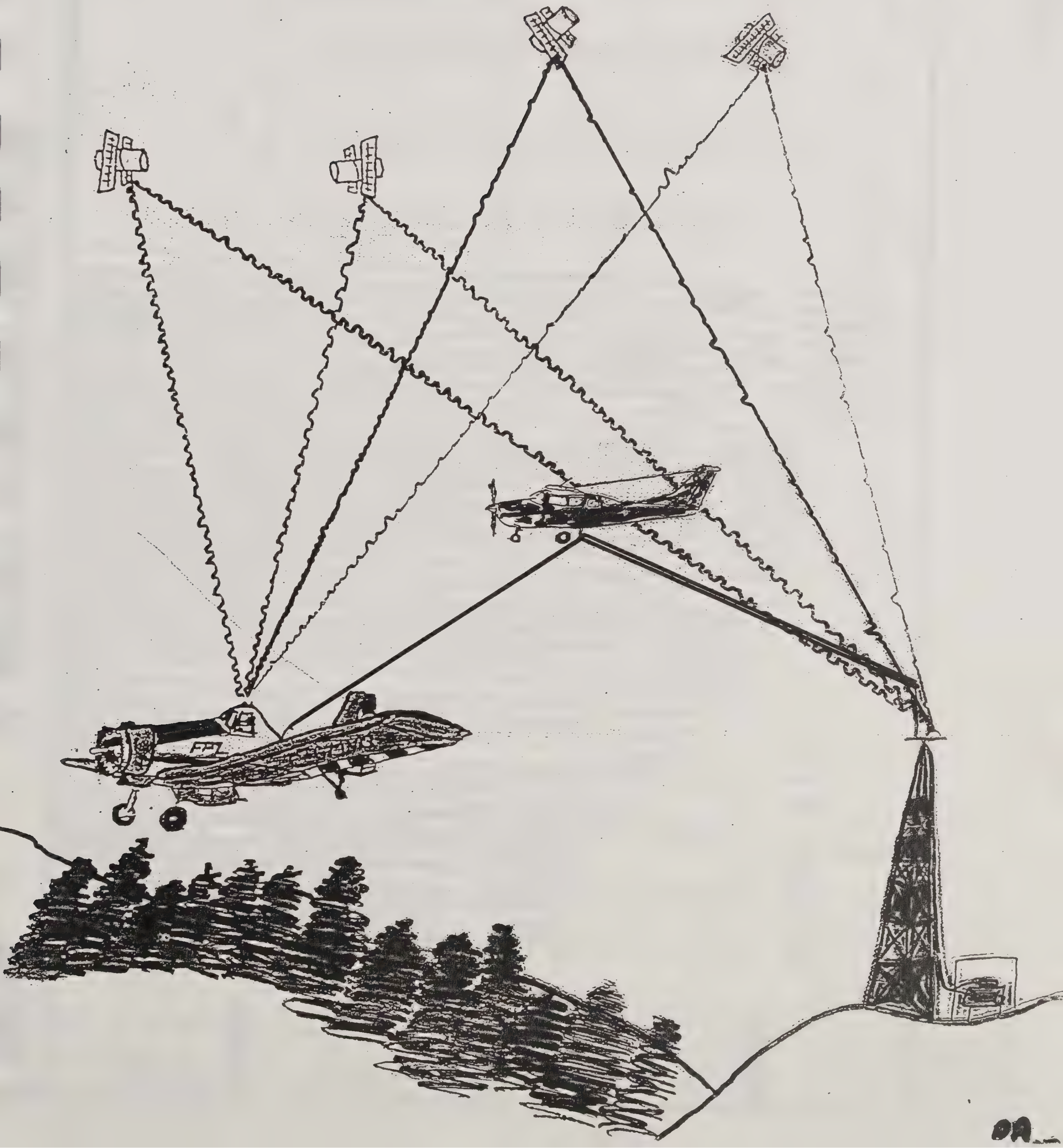
Additional datasets for model validation

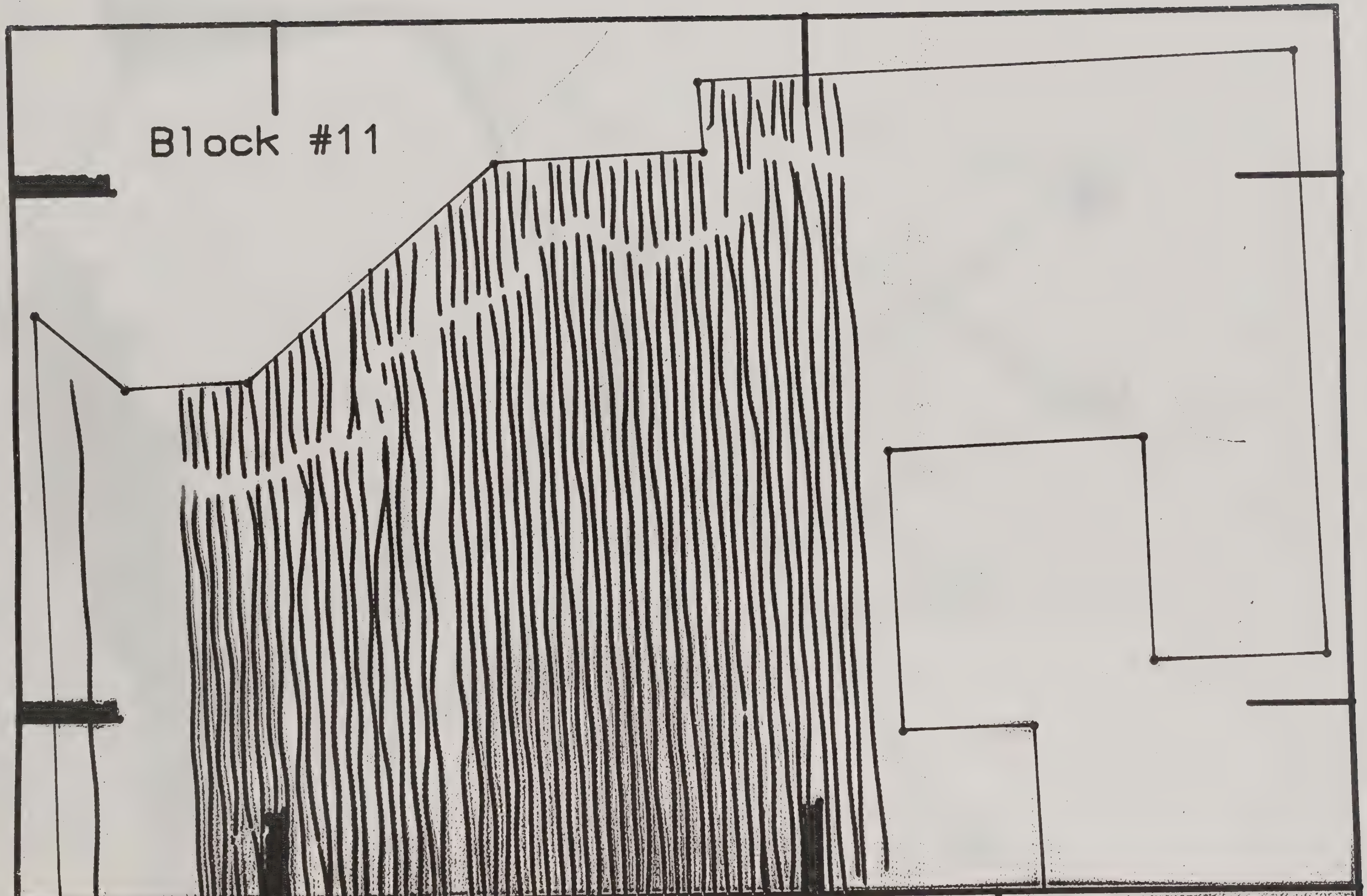
Windows user interface - will FSCBG remain stand-alone?

User support and maintenance

Dave Davies
Forest Protection Ltd.

D. DAVIES





FOREST PROTECTION LTD

TRIMFLIGHT Report - Trimble Navigation NZ 1992

Report for 1993 Spray Program
Block013 Blk #4 A 120
Line Spacing 120 m
Line direction 178 ø
Block area 2053.583 Ha
Flow Calibration 1386 pulses/litre
Autolog when PRESSURE is greater than 100.000

20/06/1993

line	Start Time hh:mm:ss	Along line at log on (m)	Along line at log off (m)	Distance (m)	Duration (sec)	Average Gnd Spd (kts)	Average Altitude (m)	Maximum Altitude (m)	Average PRESSURE	Average Flow (l/min)	Average Appln rate (l/Ha)	Total Volume (l)	Average AIR-SPEED	Average REL-HUMID	Average TEMP	Average Atom_RPM
00000031	05:13:38	-97	-53	44	1.1	81.2	52.1	58.2	152.32	37.83	1.20	0.67	0.00	0.00	0.00	0.00
00000031	05:13:41	28	6529	6502	143.4	88.2	37.1	113.1	215.63	18.46	0.67	44.10	97.47	0.90	16.25	13945.12
00000030	05:17:26	88	6498	6411	118.9	104.8	33.9	100.3	227.67	19.26	0.50	38.17	102.86	0.92	15.80	13710.81
00000029	05:20:48	69	6418	6350	131.2	92.0	31.7	86.9	217.37	18.73	0.56	41.09	99.01	0.96	15.08	13803.38
00000028	05:24:16	82	6394	6312	110.1	105.7	33.0	107.0	231.57	19.63	0.60	37.77	104.31	0.97	15.23	13685.58
00000027	05:27:40	73	6338	6265	130.4	93.4	32.0	102.4	215.64	18.71	0.54	40.64	99.49	0.94	14.79	13758.07
00000026	05:31:01	66	6278	6212	114.3	105.6	30.6	84.1	223.91	19.11	0.49	36.41	103.25	0.94	14.83	13607.26
00000025	05:34:12	80	6255	6175	126.0	95.5	30.6	84.7	218.79	18.87	0.53	39.51	101.20	0.99	14.69	13663.84
00000024	05:37:26	63	6186	6122	110.7	107.5	33.7	91.1	228.25	19.41	0.49	35.80	105.47	0.93	15.01	13519.61
00000023	05:40:38	48	6104	6056	121.7	96.8	32.4	100.0	220.89	19.01	0.53	38.54	102.31	0.92	14.98	13780.46
00000022	05:43:51	69	6092	6023	115.2	101.6	30.0	82.9	209.00	18.39	0.49	35.32	99.94	0.93	14.63	13894.50
00000021	05:47:12	158	6043	5885	110.0	98.1	30.9	82.9	227.20	19.42	0.53	37.74	103.50	0.94	14.84	13753.96
00000020	05:50:21	66	5991	5925	106.6	108.0	32.8	89.0	227.32	19.58	0.49	34.78	104.84	0.92	14.72	13745.12
00000019	05:53:31	95	5903	5809	118.2	95.5	28.2	75.3	213.13	18.71	0.53	36.85	101.00	0.94	14.51	13866.00
00000018	05:56:53	88	5908	5820	105.7	107.1	33.7	95.1	225.06	19.45	0.49	34.26	104.71	0.97	14.77	13774.31
00000017	06:00:08	100	5834	5734	115.3	96.6	29.5	96.9	206.75	18.28	0.51	35.13	101.20	0.92	14.31	13895.27
00000016	06:03:16	73	5816	5743	107.5	103.8	30.8	92.4	213.58	18.56	0.48	33.26	100.64	1.01	14.19	13796.82
00000015	06:06:47	102	5708	5606	111.8	97.4	30.1	93.9	208.88	18.45	0.51	34.38	102.11	0.93	14.21	13807.89
00000014	06:09:53	115	5682	5567	100.3	107.9	33.7	88.7	224.35	19.34	0.48	32.33	104.80	0.92	14.21	13748.52
00000013	06:12:58	112	5686	5574	106.6	101.6	37.9	104.5	218.83	18.84	0.50	33.48	105.85	0.91	14.40	13773.58
00000012	06:15:56	91	5600	5509	100.2	106.8	35.4	98.1	207.99	18.38	0.47	30.71	104.40	0.92	13.95	13769.18
00000011	06:18:57	109	6298	6189	118.3	101.7	31.2	81.7	203.33	18.13	0.48	35.74	105.15	0.92	13.41	13882.75
00000010	06:22:00	54	5488	5434	96.8	109.1	35.4	90.5	206.84	18.31	0.45	29.55	106.49	0.98	12.80	13781.92
00000009	06:25:05	110	5435	5325	98.5	105.1	30.1	60.7	205.04	18.30	0.47	30.03	109.27	0.91	12.91	13753.99
00000008	06:27:45	126	5373	5247	94.5	107.9	32.3	75.3	210.09	18.60	0.47	29.30	106.64	0.98	12.26	13961.02
00000007	06:31:01	77	5346	5269	100.3	102.1	31.0	74.7	193.42	17.73	0.47	29.64	105.45	0.98	13.68	14017.00
00000006	06:33:52	106	5306	5200	94.6	106.9	30.9	78.0	202.88	18.15	0.46	28.61	103.90	0.92	13.66	14056.41
00000005	06:36:50	113	5252	5139	98.9	101.0	26.7	61.6	192.64	17.32	0.46	28.56	104.01	0.95	14.49	14063.45
00000004	06:39:40	63	5211	5148	98.9	101.2	29.9	74.7	184.15	17.03	0.45	28.07	97.75	0.98	14.19	14126.39
00000003	06:42:44	103	5138	5035	98.8	99.1	32.0	95.7	190.06	17.11	0.47	28.18	102.21	0.93	15.01	14116.38
00000002	06:45:23	57	2161	2104	42.2	96.9	27.4	62.2	169.22	14.30	0.40	10.05	95.31	0.90	13.42	14295.02

SESSION SUMMARY

TOTAL DISTANCE	169.734 km
AVERAGE GND SPEED	101.1 kts
AVERAGE GPS HEIGHT	391.2 m
AVERAGE ALTITUDE	31.96 m
AVERAGE PRESSURE	212.787
AVERAGE FLOW	18.564 l/min
APPLICATION RATE	0.496 l/ha
TOTAL VOLUME	1009.260 l
AVERAGE AIR-SPEED	102.789
AVERAGE REL-HUMID	0.941
AVERAGE TEMP	14.455
AVERAGE Atom_RPM	13830.739
TOTAL TIME	00:54:22 sec
AREA COMPLETED	2036.814 Ha
% AREA COMPLETED	99.2 %

Table Data Summary Sheet For 1993 Insecticide Application

OPTIMIZE TARGET DEPOSIT/

MINIMIZE OFF TARGET DEPOSIT

Meteorological Conditions
(Stability, Wind Speed/Direction, Temperature)

↕ **Real-Time?**

Spray Deposit Model

↕ **Real-Time?**

GPS Aircraft Tracking System
(Real-Time Adjustments)

Jack Barry
USDA Forest Service, FHTET

United States Department of Agriculture | Forest Service | FHTET - Davis Washington Office | 2121 C Second Street
Davis, CA 95616
PH (916) 757-8341
FAX (916) 757-8383

File Code: 2150

Date: June 5, 1996

Subject: Review of FSCBG

To: Brian Richardson
Harold Thistle
Bob Mickle

Thanks for taking the time to review the 1982 Weeks, et al report titled Recommended development plan for an aerial spray planning and analysis system and providing comments. As you recall, I asked you to rate progress on each of the FSCBG development recommendations following the procedure followed by Brian. Results are enclosed. I will ask Milt to share his comments at Phoenix now that he has heard from representative users.

Jack

JOHN W. BARRY
Director,
FHTET-Davis

Enclosure

cc: Milt Teske (CDI) w/enc.
John Ghent (Asheville FO) w/enc.
Dan Twardus (NA) w/enc.
John Weeks w/enc.

1996 Status of FSCBG and Related DSS Enhancements - Opinions of Four Reviewers

Spray Modeling Need [1]	Progress to date (1996) (0 = no progress, 10 = completed) [2] Brian R.	Harold T.	Bob M.	Jack B.	Remarks
Deposition calculation for all heights simultaneously.	10	3	0	3	Need better graphics; specific to individual types of leaves; need crop canopies. (JB)
Simplified input of droplet spectra.	5	9	10	9	The Droplet Database is big improvement but model to generate distributions from physical characteristics would be ideal. (BR) What about SDTF's atomization model? (JB)
Simplified input of stand description data.	7	7	10	5	LiCor capability is good simplification but validation required. (BR) Data base from eastern forests being added this year. (JB)
Summary display programs.	8	7	7	7	FSCBG has greatly improved graphics. Windows interface would be better. DSS systems incorporating FSCBG will help. (BR)
Interactive program control.	8	9	8	7	Comment as above. (BR)
Effective wind speed correction.	?	5	5?	5	I don't use this module. (BM)
Improvements in the impaction model.	?	5	7	4	Need more visibility of this capability. (JB)
Test evaporation routine using existing data.	7	8	8	7	While a lot of this important work is completed by SDTF, it is inaccessible to other groups. (BR) Need better documentation. (JB)
Alter the program to allow model runs w/any flight pattern.	9	6	5	2	Model capability not clear but sure need GIS & real-time capability. (JB)
Alter the simulation to allow forest edge effects beyond the canopy.	0	2	0	0	There is particular interest in effects of shelterbelts on spray drift attenuation. (BR)
Deposition accounting by tree type.	7	5	5	2	Three canopy storeys seems adequate. (BR) I don't really use this. (BM) Need to incorporate various orchard types. (JB)
Slope correction for canopy penetration.	0	5	0	2	Need for dispersion if VALDrift does not work as intended. (JB)

1. Weeks, J.A., H.R. Blacksten, and S.D. Coffey. 1982. Recommended development plan for an aerial spray planning and analysis system. FPM 82-2. Prepared under USDA Forest Service contract, Region 5, 53-91S8-0-6406, by Ketron, Inc., Arlington, VA. USDA Forest Service, Forest Pest Management, Davis, CA.

2. B.R. = Brian Richardson, H.T. = Harold Thistle, B.M. = Bob Mickle, J.B. = Jack Barry

1996 Status of FSCBG and Related DSS Enhancements - Opinions of Four Reviewer

Spray Modeling Need	Progress to date (1996) (0 = no progress, 10 = completed) Brian R.	Harold T.	Bob M.	Jack B.	Remarks
Improved fitting of impaction coefficient and probability of penetration.	?	5	?	4	LiCor LAI 2000 (if validated) gets around problem of defining probability of penetration. (BR) Relates to above questions. (JB)
Near site drift measure of hazard.	0	5	9	4	New DSS developments incorporating FSCBG will assist here. (BR) Can do but not easily. (JB)
Herbicide measure of effectiveness.	0	4	9	2	See above comment. (BR)
Simple insecticide measure of effectiveness.	0	4	5	2	See above comment. (BR) GYPSES DSS is working on this. (JB)
Sensitivity analysis.	7-10	9	10	9	Thorough analyses completed; incorporate results into DSS. (BR) Awaiting report from Milt Teske. (JB)
Aerial spray mission cost computation.	0?	9	10	8	Not incorporated into FSCBG but various models (e.g. CASPR) available. Costings to be incorporated into various DSS software. (BR) Different prog. - incorporate in FSCBG? (BM)
Interim documentation.	10	9	10	9	
Research data on modes of toxicity.	0	6	0	0	Excellent models available in Europe. Consider integration with current DSS software under development? (BR) This is an important area for future work. (JB)
Droplet spectra data.	5	8	5	9	Always need more data. SDTF has excellent but inaccessible database. Model to predict droplet size distribution required. (BR) Should include new Malvern data. (BM) Is anyone else going to share data! (JB)
Additional foliage distribution descriptions.	5	8	8	5	Relatively simple task if LiCor LAI 2000 module is validated. (BR)
Improved wake model.	8	9	10	9	Importance of asymmetry of wake due to rotor/prop. rotation? (BR)
Simplified $o\sim_A$ and $o\sim_E$ input.	7?	6	9	6	

1996 Status of FSCBG and Related DSS Enhancements - Opinions of Four Reviewer

Spray Modeling Need	Progress to date (1996) (0 = no progress, 10 = completed) Brian R.	Harold T.	Bob M.	Jack B.	Remarks
Simplified wind profile generation.	7?	6	6	6	
Persistence and photodegradation model	0	2	0	0	Excellent models available in Europe. Consider integration with current DSS software under development? (BR) Need to incorporate this in future update. (JB)
Dosage prediction within the canopy.	7?	4	?	0	Dosage not needed by FS - only total dose of AI. (JB)
Routine to adjust model predictions based on field managements.	0	2	0	0	
Empirical impaction model.	0	5	5	5	
Mesoscale model interface.	5-7	3	3	0	Presumably VALDRIFT has gone some way to meeting this need. (BR) Harold will present paper at 1996 ASAE meeting. (JB)
Improved insecticide effectiveness module.	0?	2	0	0	GYPSES/ASPEX? (BR) Just beginning this important work. (JB)
Model validation.	8	8	8	8	Important to validate new developments. (BR) Need sponsors for future work. (JB)
User documentation.	8	8	9	9	Important to upgrade with new developments. (BR)
Maintenance documentation.	8	2	8?	2	See above comment. (BR)
Empirical evaporation descriptions for major formulations.	3-5	8	6	8	Large database may be available eventually from SDTF? (BR) I believe that pure water evaporation is accurate enough. (BM) Not sure for some of our Bt formulations. (JB)
Spray adjuvant effects.	3-5	3	9	0	See above comment. (BR) Incorporate into conversion spectrum. (BM) Looking at adjuvants is an endless journey - not practical for modeling. (JB)
Synopsis versions for portable calculators.	0	8	8	?	Not relevant anymore with PCs. (BR)
Synopsis documentation.	0	8	0?	?	Not relevant. (BR)
Parameterization of the Monte Carlo simulation.	0	5	0		Model runs fast enough as is. (BM)

1996 Status of FSCBG and Related DSS Enhancements - Opinions of Four Reviewer

Spray Modeling Need	Progress to date (1996) (0 = no progress, 10 = completed)				Remarks
	Brian R.	Harold T.	Bob M.	Jack B.	
Adaption of crop canopy deposition model.	0	3	8	0	Interactions of wake with canopy is of interest. (BR) Need field data on above canopy influence of spray cloud. (JB)
Synopsis version of open area model.	0	0?	0	0	Not relevant. (BR)
Further validation.	8	8	8	8	Required as new developments are added to system. (BR)
Update user and maintenance documents.		9	8	6	Required as new developments are added to system. (BR) Ongoing. (BM)

Nick Woods
CPAS Univ. of Queensland
Australia

Head of Department: Associate Professor Ken Rickert

THE CENTRE FOR PESTICIDE APPLICATION AND SAFETY (C-PAS)
Director: Nicholas Woods

THE UNIVERSITY OF QUEENSLAND
GATTON COLLEGE
Lawes Qld 4343 Australia
Telephone (074) 601 281
International +61 74 601 281
Facsimile (074) 601 283
Email nwoods@jabiru.uqg.uq.oz.au

NATIONAL SPRAY MODEL AND APPLICATION TECHNOLOGY STEERING COMMITTEE PHOENIX, AZ JULY 1996

SPRAY DRIFT RESEARCH - AUSTRALIA

Nicholas Woods
Director
The Centre for Pesticide Application & Safety

The Centre for Pesticide Application and Safety (C-PAS) is a national scientific research and training group located at the University of Queensland Gatton College, near Brisbane, Australia. Equipped with a wide range of specialist sampling and analytical equipment, the Centre provides a wide range of research and consultancy services to industry and government, in pesticide application areas relevant to agriculture, forestry and public health.

As reported in 1994, as part of a major national research programme, the Centre has been commissioned over the last 3 years to investigate the aerial off-target transport of pesticides in the cotton industry. In particular, the Ultra Low Volume (ULV) and Low Volume (LV or EC) aerial application of endosulfan has been investigated.

Supported by aircraft testing, calibration and Malvern droplet size measurements, two methods of analysis have been used :-

1) Full field treatment monitoring (including far downwind measurements of airborne spray drift)
2) Simultaneous single flight line (SFL) analysis (comparative treatments using different formulations / nozzles)

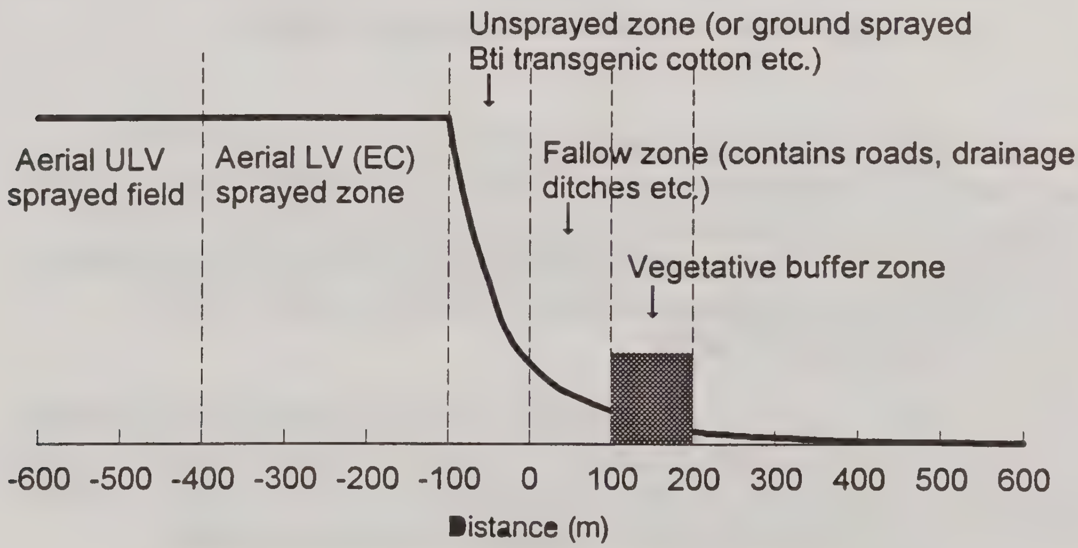
Trials have typically involved measurement of drift fallout (horizontal deposition) using horizontal collectors and airborne drift using vertical collectors and 20m high towers placed up to 1 km downwind.

Emphasis was originally placed on assessing the impact of pesticides in the riverine environment, but investigations were later extended to encompass contamination of neighbouring crops and pastures using high collection efficiency artificial targets, (eg. pipe cleaners, mosquito netting).

Computer modelling using simple Gaussian diffusion theory and the FSCBG model (no canopy) has been undertaken to provide a theoretical framework for the experimental field data gathered so far. Generally there has been good correlation between actual and predicted fallout levels.

The overall objective of this work is not to necessarily prohibit ULV spraying, but to examine its characteristics so that an efficient ULV/placement application system can be developed and maintained. Information from this study is being used to develop effective spray management strategies (ie. Best Management Practice). A central feature of such a strategy may be the use of a buffer zone system similar to that illustrated below.

Figure 1. Proposed spraydrift management scenario utilising buffers



Contributions would be welcome from the committee on the following :-

1) alternative canopy models for FSCBG

2) simple drift prediction algorithms for incorporation with GPS technology

Dave Whiteman
Battelle NW Labs

Dave Whiteman

National Spray Model and Application Technology
Steering Committee Meeting

July 18, 1996
Phoenix, Arizona

- At the 1991 committee meeting in Blacksburg, Virginia:

Recommendation - "A manual describing complex terrain meteorological phenomena and their effects on aerial spraying operations should be commissioned. The manual should provide useful rules of thumb, simple algorithms for making relevant meteorological calculations, nomograms, tables, etc. that would be useful for the planning and conduct of aerial spraying operations."

- Funding for this manual, but with a broadened scope to appeal to other agencies, was assembled late last year and the manual is now being written.

- Funding agencies:

U.S. Forest Service
    Forest Health Technology - Jack Barry
    Missoula Technology & Development Center - Harold Thistle
U.S. Army
    Dugway Proving Ground - Bruce Grim
National Weather Service
    Fire Weather Program - Paul Stokols
Department of Energy
    Pacific Northwest National laboratory - Dave Whiteman

- An Editorial Advisory Committee was formed, and met in SLC in January to approve the outline of the manual and to provide guidance, review and other support.

Editorial Advisory Committee members include:
    all the above, plus Rusty Billingsley, Carl Gorski and Andy Edman, NWS

- An outline of the manual is attached.

- The manual is now being written and color graphics are being produced for it. There is also activity in arranging for publication of the finished manual.

- Schedule:

Draft of main meteorology chapters by early Fall
Drafts of applications chapters by mid-Winter
Completed document by Spring

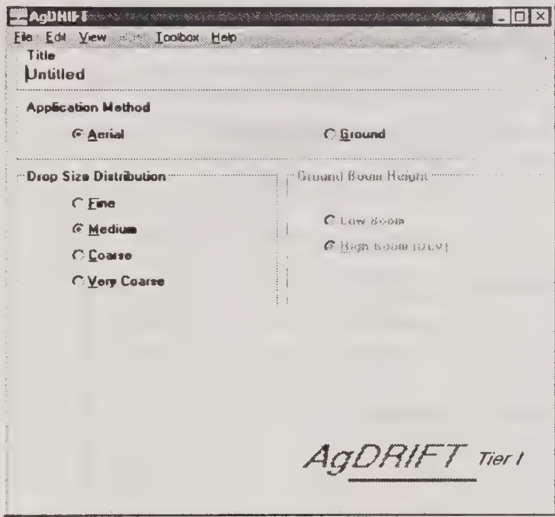
TENTATIVE OUTLINE

Complex Terrain Meteorology - A Manual for the Natural Resource Manager

C. David Whiteman

Dave Esterly
Dupont Agri. Products

Windows Based Programming for Ease of Use

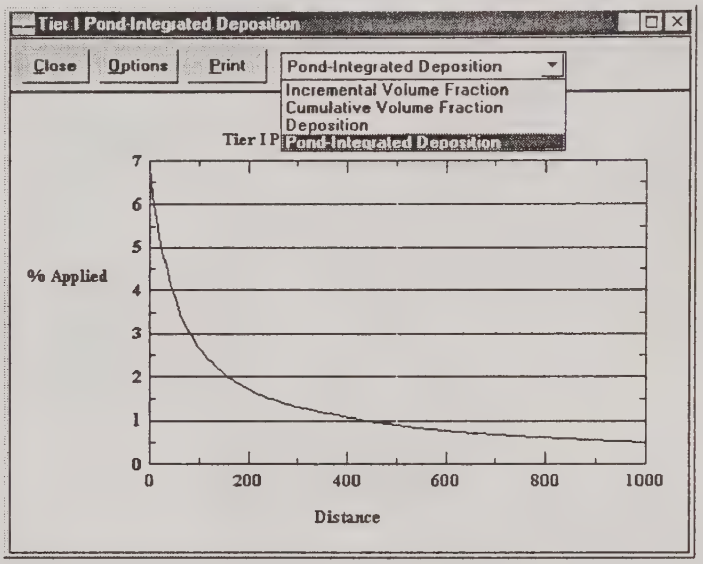


Select Application Method

Select Subclasses by Drop Size Distribution

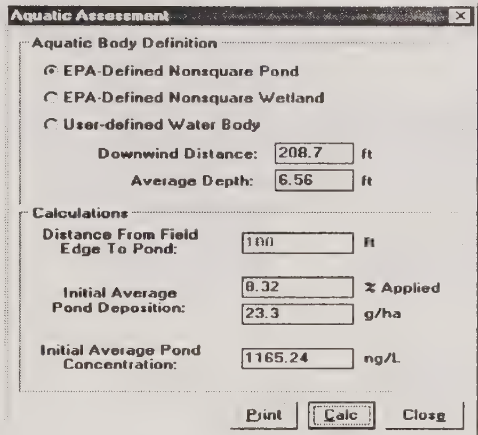
DME sterly 6/7/96

Pull Down Menus: Let the User View the Results in Severals Ways



DME sterly 6/7/96

AgDRIFT Uses Standard Case



Choices

- Wet Lands
- Ponds
- User Defined

You Can Ask the Same Question Many Ways

DME sterly 6/7/96

AgDRIFT: Tiered Structure

Each Tier Requires Increasing Knownledge of Application Method:

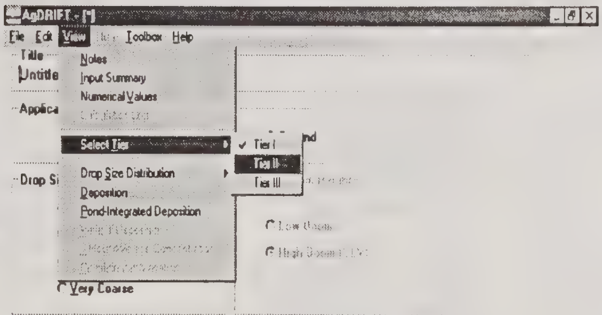
Tier I: Quick Overview "Worst Case " Few Restrictions on Application Method or Timing.

Tier II: Model Inputs Matched to Application Timing and Locale Meteorological Conditions.

Tier III: Designed for Incident Investigation, Training, Experimenting, etc.

DME sterly 6/7/96

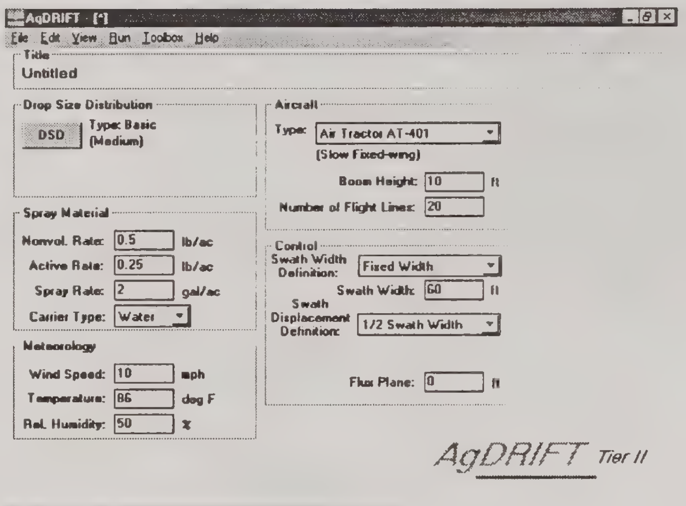
AgDRIFT: Tiered Structure



AgDRIFT Tier I

DME sterly 6/7/96

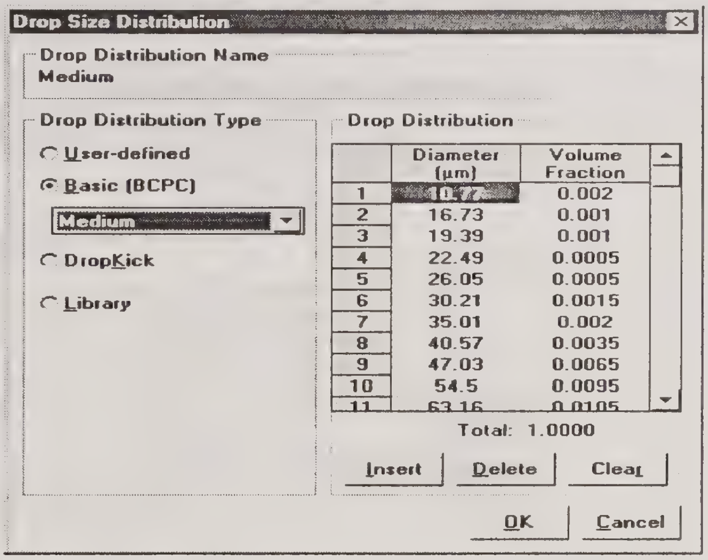
Tier II : Allows the User on Control Many of the Inputs Variables:



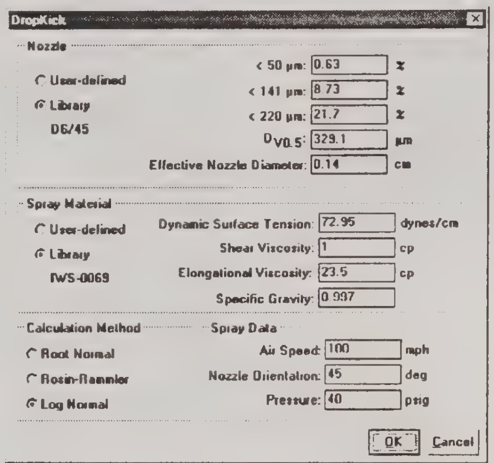
- Drop Size
- Spray Material
- Meteorolagy
- Aircraft Type
- Swath Control

DME sterly 6/7/96

The Drop Size Distribution Can Be Provided Several Ways.

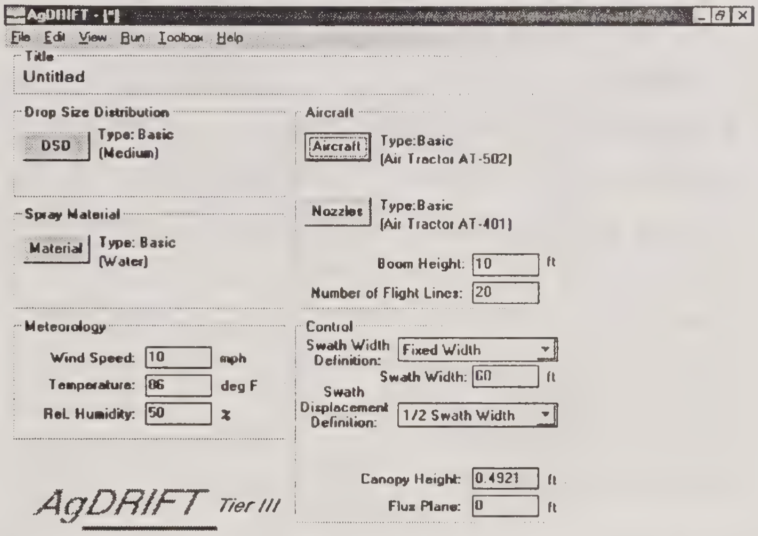


And "Drop-Kick" Will Estimate the Drop Size Distribution Without Costly Wind Tunnel Studies.



DME sterly 6/7/96

Tier III User to Control Equipment Specifications



DME sterly 6/7/96

CRADA Status

DONE

- Proposed Tier I Issued for Review.
- Tier II & III Aerial Programming Complete.
- User Manual, DRAFT
- Aircraft and Nozzle Data Bases installed

WORKING

- Report on Model Validation
- Add Tier III Data Bases.
- Develop Orchard Model.
- Add Field Studies Data Base.

Version 2 Will Include Probabilistic Modeling for Multiple Apps.

DME sterly 6/7/96

Collective Cooperation

• Sandy Bird	EPA-ORD Athens GA
• Steve Perry	EPA-ORD RTP NC
• Milt Teske	Continuum Dynamics Inc
• Scott Ray	DowElanco
• Dave Davis	AmCy
• Dave Gustafson	Monsanto
• Ian Hill	Zeneca
• Bob Graney	BAYER
• Fred Bouse	NAAA USDA (ret)
• Dave Esterly	Dupont

DME sterly 6/7/96

Acknowledge

- John (Jack) Barry, USDA Forestry Service, who insight kept AgDisp and FSCBG spray application models running for so many years.

  Good Luck, Jack

DME sterly 6/7/96

Brian Richardson
New Zealand Forest Research Institute

National Spray Model and Application Technology Steering Committee Meeting

Current and future research directions in New Zealand Forestry

Brian Richardson

July 1996

Introduction

Over the next two years, the priority area for pesticide application research in New Zealand forestry is SpraySafe Manager (SSM) development, a collaborative project between the New Zealand Forest Research Institute (FRI) and the USDA Forest Service. The objective of SSM is to provide anyone involved with aerial herbicide applications with a simplified means of accessing the power of FSCBG. The unique feature of this system will be the integration of output from FSCBG with dose-response models of herbicide/weed and herbicide/sensitive crop combinations. This will allow users to quantitatively assess the biological consequences of different application methods. The most important features of SSM include: * Prediction of buffer zone requirements based on a defined spraying scenario, herbicide type, and sensitive species.
* Prediction of overall weed control (efficacy). * Prediction of productivity or operation cost.

A detailed summary of SSM was presented at the ASAE meeting (Paper number 961057).

A number of specific projects are in progress, directly related to SSM developments, and these are summarised below.

1. SpraySafe Manager Interface Development

A SpraySafe Manager prototype was developed in December 1995 in a collaborative project with FRI and the USDA Forest Service, represented by Dr Milt Teske. Dr Milt Teske made appropriate modifications to FSCBG, producing FSCBG/NZ, and this was incorporated into the interface developed by FRI. The prototype has been distributed to industry collaborators in NZ and is currently being evaluated.

A programmer has been employed specifically to design and implement Version 1 of SSM. Work on the system will commence as soon as comments from industry on the prototype have been thoroughly evaluated. Initial reactions were very positive. Further input from Dr Teske, towards the end of Version 1 software development, would be desirable.

2. Dose-response models

A key element essential to SSM is the development of a database of biological response models. John Ray from FRI has been co-ordinating this work. Key herbicide/sensitive species and herbicide/weed species combinations relevant to forestry situations have been identified and

prioritised and laboratory studies to generate dose-response models are underway. The attached paper summarises procedures and some results. Consideration should be given to incorporating species and herbicides in the database that are relevant to the USA and other countries.

3. Non-volatile fraction

At present, the assumption is made that the herbicide formulation (i.e. the product) in the spray mix is essentially non-volatile and this is specified as the non-volatile fraction. The reality is, however, that a considerable proportion of the formulation may also be volatile. The Spray Drift Task Force have information on the non-volatile fraction of a large number of products but these data are not publicly available as yet. A project will be initiated to determine the non-volatile fraction key herbicide formulations relevant to SSM.

4. Sensitivity analysis

While Dr Teske was in New Zealand he undertook an extensive sensitivity analysis of FSCBG. Results from this analysis will be included in a database within SSM so that the general effects of application variables on drift (buffer distances), efficacy, or productivity can be examined without actually running the models.

The FRI/USDA Forest Service also have a commitment to use the results from this analysis to develop a concise educational document, written for people at the field operational level. The field guide will illustrate only the most important aerial application principles and safety considerations, and will promote the application of pesticides in a responsible, safe, and consistent manner. A second and subsequent consideration will be the development of a more comprehensive but practical aerial application reference manual, of value to operational managers. It would include information on all important application variables, and key interactions among variables, as well as comprehensive discussions on meteorology, safety, calibration etc.

5. Other considerations

The Forest Research Institute will continue to encourage development and enhancement of FSCBG. Priority areas for further work include:

* Validation of LiCor canopy description option.

* Development of a database of LiCor characteristics of important weed species. This work will commence in New Zealand within the next 6 months.

* Incorporation of discrete canopy (shelterbelt) option into FSCBG.

* Implementation of VALDRIFT

* Enhancing FSCBG to include airblast, ground sprayers, and solids application options.

Finally, we would like to strongly recommend that FSCBG should be maintained and further developed as a stand-alone system.

Appendix C

List of Committee Members /
Past Attendees / Others

Committee Members / Past Attendees / Others August 1996

National Spray Model and Application Technology Steering Committee

Linda Abbott (APHIS, BBEP)
USDA Health Inspection Service
4700 River Road, Unit 149
Riverdale, MD 20737-1228
PH (301) 734-5170
FAX (301) 734-5992

Bill Bagley
Wilbur-Ellis
6307 Ridge Pass
San Ontonio, TX 78233
PH (210) 657-0953
FAX (210) 657-4580

Larry Barber
USDA Forest Service
Forest Pest Management
P.O. Box 2680
Asheville, NC 28802
DG L.Barber:S29A
PH (704) 257-4323
FAX (704) 257-4840

John (Jack) W. Barry
USDA Forest Service
Forest Health Protection
3123 Beacon Bay Place
Davis, CA 95616
DG J.Barry:R05H
PH (916) 757-8342 or (916)758-2561
FAX (916) 757-8383

Terry Biery
910 AG/DOS
3976 King Graves Rd.
Youngstown-Warren RGL APRT
ARS OH 44473-0910
PH (330) 392-1178
FAX (330) 392-1161

Sandy Bird
US Environmental Protection Agency
Environmental Research Lab.
College Station Road
Athens, GA 30613
PH (404) 250-3372
FAX (404) 250-3340

Fred Bouse
PO Box 260
Wellborn, TX 77881
PH (409) 690-2350

Jim Brown
NAVDISVECTECOLCONCEN JAX.
NAVY DISEASE VECTOR ECOLOGY
AND CONTROL CENTER, BOX 43
NAS, JACKSONVILLE FL 32212-0043
PH (904) 772-2424
FAX (904) 779-0107

Parshall Bush
Ag Ser Lab
Univ. of Georgia
110 Riverbend Rd
Athens, GA 30605
PH (706) 542-9023
FAX (706) 542-1474

Scott Cameron
Union Camp Corporation
PO Box 216
Rincon GA 31326
PH (912) 826-5556
FAX (912) 238-6719

Dave Davies
Forest Protection
2240 Lincoln Road
Fredericton, NB E3B 7E6
PH (506) 446-6930
FAX (506) 446-6934

Richard Dirksen
O'Reilly Rab Hall
Dept of Agricultural and
Biological Engineering
Cornell University
Ithaca, NY 14853
PH (607) 255-2495
FAX (607) 255-4080

Bov Eav
Forest Service-USDA
Forest Health Enterprise Technology Team
3825 E. Mulberry Street
Fort Collins, CO 80524
DG B.Eav:W04A
PH (970) 498-1784
FAX (970-498-1660

Dave Esterly
DuPont Agricultural Products
Experimental Station
Wilmington, DE 19880-0402
PH (302) 695-1690
FAX (302) 366-5467

Robert Fox
USDA/ARS
Ohio State Univ.
Food, AGR, and BIOL ENGR
OARDC
1680 Madison Ave.
Wooster, OH 44691
PH (330) 263-3871
FAX (330) 263-3670

Robert A. Fusco
Manager, Forestry-Vector
Field R&D
Abbott Laboratories, Dept. 986
HC 63, Box 56
Mifflintown, PA 17059
PH (717) 436-5043
FAX (717) 436-5184

John Ghent
Forest Service-USDA
PO Box 2680
Asheville, NC 28802
DG J.Ghent:S29A
PH (704) 257-4320
FSX (704) 257-4840

Bruce Grim
ATTN: STEDP-WD-M-MA (Bruce Grim)
Dugway, UT 84022
PH (801) 831-5101
FAX (801) 831-5289

Jim Hadfield
USDA Forest Service
Eastern Washington Forest Health Office
Forest Sciences Laboratory
1133 N. Western Ave
Wenatchee, WA 98801
DG J.Hadfield:R06F17A
PH (509) 664-2777
FAX (509) 664-2742

Dan Haile
Modeling & Bioengineering Research Unit
Medical & Veterinary Entomology
 Research Laboratory
PO Box 14565
1600 S.W. 23rd Drive
Gainesville, FL 32604
PH (352) 374-5928
FAX (352) 374-5834

Franklin Hall
Laboratory for Pest Control
 Application Technology
Ohio Agricultural Research
 and Development Center
1680 Madison Avenue
Wooster, OH 44691-4096
PH (216) 263-3726
FAX (216) 263-3686

Clarence Hermansky
Dupont Agricultural Products
Experimental Station
PO Box 80402
Wilmington, DE 19880-0402
PH (302) 695-1816
FAX (302) 695-7804

Andrew Hewitt
Chairman of Technical Committee
Stewart Agricultural Research Services Inc
PO Box 509
Macon, Missouri 63552
PH (816) 762-4240
FAX (816) 762-4295

Kevin Howard
USDA-ARS
P.O. Box 36
Stoneville, MS 38776
PH (601) 686-5240
FAX (601) 686-5422

Harry Hubbard
USDA FS Center for Biological Control of NE
Forest insects & Diseases
51 Mill Pond Rd.
Hamden, CT 06514
PH (203) 734-9168
FAX (203) 230-4315

Ellis Huddleston
Dept. of Entomology, Pathology
and Weed Science
New Mexico State Univ.
Las Cruces, NM 88003
PH (505) 646-3934
FAX (505) 646-5975

Bill Jorden
PO Box 36373
Tucson, AZ 85740
PH (520) 297-4017
FAX (520) 297-3490

John Kennedy
13 "C" Street, Suite G
Laurel, Maryland 20707
PH (301) 490-1600
FAX (301) 490-5793

I. W. (Buddy) Kirk
USDA-ARS
231 Scoates Hall TAMU
College Station, TX 77843-2122
PH (409) 260-9364
FAX (409) 260-9367

Steve Knight
USDA APHIS, PPQ DEO
4700 River Road, Unit 134
Riverdale, MD 20737-1228
PH (301) 734-7935
FAX (301) 734-8584

Alina MacNichol
Continuum Dynamics, Inc.
P.O. Box 3073
Princeton, N.J. 08543
PH (609) 734-9282 EXT 109
FAX (609) 734-9286

Robert E. Mickle
Air Quality Process Research Division
Atmospheric Environment Services
4905 Dufferin Street
Downsview, Ontario
Canada M3H 5T4
PH (416) 739-4851
FAX (416) 739-5708

Karl Mierzejewski
710 Toftrees Avenue
State College, PA 16803
PH (814) 238-6857

David R. Miller
Univ. of Connecticut
308 W.B. Young Building
1376 Storrs Road
Storrs, CT 06268
PH (203) 486-2840
FAX (203) 486-2504 or 5408

Mike Newton
Forestry Sciences Lab. 020
Oregon State Univ.
Corvallis, OR 97331-7501
PH (541) 737-6076
FAX (541) 737-1393

C. S. Parkin
Cranfield University
Silsoe College, Silsoe
Bedford MK 45 4DT
United Kingdom
PH +44 (0) 528 860428
FAX +44 (0) 525 861527

Jules Picot
University of New Brunswick
Dept. of Chemical Engineering
PO Box 4400
Fredericton, New Brunswick
Canada E3B 5A3
PH (506) 453-3542
FAX (506) 453-3591

Mark Quilter
State of Utah
Department of Agriculture
Division of Plant Industry
350 North Redwood Road
Salt Lake City UT 84116
PH (801) 538-9905
FAX (801) 538-7126

Jim Rafferty
U.S. Army Dugway Proving Ground
Attn: STEDP-WD-M-MA (Jim Rafferty)
Dugway, UT 84022
PH (801) 831-5101
FAX (801) 831-5289

John Ray
Forest Research Institute
Private Bag 3020
Rotorua, New Zealand 82179
PH 011 6473 475516
FAX 011 6473 479380

Brian Richardson
Forest Research Institute
Private Bag 3020
Rotorua, New Zealand 82179
PH 011 6473 475516
FAX 011 6473 479380

Tim Roland
USDA APHIS, PPQ
Aircraft Operational
Rt. 3 Box 1001
Edinburg, TX 78539
PH (210) 580-7388
FAX (210) 580-7389

Bob Sanderson
Dept. of Entomology
New Mexico State Univ.
Box 30003/Dept. 3BE
Las Cruces, NM 88003-0003
PH (505) 646-3543
FAX (505) 646-5975

Pat Skyler
USDA Forest Service
Forest Pest Management
2121-C 2nd Street
Davis, CA 95616
DG P.Skyler:R05H
PH (916) 757-8343
FAX (916) 757-8383

Dave Smith
Dept. of AG & Biological Engineering
P.O. Box 5465
Mississippi State Univ.
Mississippi, 39762
PH (601) 325-3282
FAX (601) 325-3853

Doug Sommerville
US Army ERDEC
ATTN: SCPRD-RTC
Bldg. 3160
Aberdeen, MD 21010
PH (410) 671-2570
FAX (410) 285-1505

Bill Steinke
Biological & Agricultural
Engineering Extension
University of California
Davis, CA 95616-5294
PH (916) 752-1613
FAX (916) 752-2640

Milt Teske
Continuum Dynamics, Inc.
P.O. Box 3073
Princeton, N.J. 08543
PH (609) 734-9282 EXT 109
FAX (609) 734-9286

Harold Thistle
Missoula Technical Development Center
Ft. Missoula - Bldg. 1
Missoula, MT 59801
DG H.Thistle:R01A
PH (406) 329-3981
FAX (406) 329-3719

Dave Thomas
USDA Forest Service
Forest Pest Management (AB-2S)
PO Box 96090
Washington, D.C. 20090-6090
DG D.Thomas:W01C
PH (202) 205-0889
FAX (202) 205-1139

Dave Valcore
DOW/ELANCO
9410 Zionsville Rd.
S. Campus Bldg. 304
Indianapolis, IN 46268
PH (317) 337-7933
FAX (317) 337-7922

Dave Whiteman
Battelle Pacific NW Labs
Battelle Blvd.
P.O. Box 999
Richland, WA 99352
PH (509) 372-6147
FAX (509) 372-6168

Keith Windell
USDA Forest Service
PO Box 7669
Missoula, MT 59807
DG K.Windell:R01A
PH (406) 329-3956
FAX (406) 329-3132

Jeff Witcosky
USDA Forest Service
P.O. Box 2680
Asheville, NC 28802
DG J.Witcosky:S29A
PH (704) 257-4843
FAX (704) 257-4840

Al Womac
Ag. Eng. Dept.
Univ. of Tennessee
P.O. Box 1071
Knoxville, TN 37901-1071
PH (615) 974-7266
FAX (615) 974-4514

Nicholas Woods
Univ. of Gueensland
C-PAS, Gatton College
LAWES, QLD
Australia 4343
PH +61 74 601293
FAX +61 74 601283

Heping Zhu
USDA/ARS
Ohio State Univ.
Food, AGR, and BIOL ENGR
OARDC
1680 Madison Ave.
Wooster, OH 44691
PH (330) 263-3868
FAX (330) 263-3670